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THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

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Chronicle and Comment

"Phaeton" Coming Into Use

THE 1923 Handbook of Automobiles, recently issued by the National Automobile Chamber of Commerce, indicates that the recommendation of the Passenger-Car Body Division in reference to the use of the name "phaeton" instead of "touring car" is meeting with approval. This Handbook shows that 20 companies are now using that name for various types of open car.

Geography of Society Membership

THE following table shows approximately what proportion of the members of the Society reside in different regions of the United States and how many are located outside of this Country; the total number on the rolls of the Society being about 5300.

	Per Cent
Great Lakes States	47
Middle Atlantic States	31
New England States	8
Middle Western States	5
Pacific Coast States	4
Southeastern States	1
Foreign	4

Research Information Service

THE attention of the members is directed to the unique facilities offered by the Research Department Information Service. A complete index of the Society's publications, together with an exhaustive index covering domestic and foreign publications in the automotive and allied fields, is kept on file and is available for reference.

In addition to the published bibliographies indexed, the Department has unpublished bibliographies and lists of references that are invaluable for preliminary work along research lines. They include many of the important debatable subjects, such as lubrication; heat application to internal-combustion engine fuels; gears; magneto ignition; highway problem; chassis springs; steel, wire, and wood wheels and metallurgical matters. Copies of these bibliographies are held in the Department and may be had on request.

The Research Department has innumerable contacts with investigators and commercial and university laboratories, and is able to furnish data on researches projected, in progress or completed. Published reports of investigations, abstracts, indexes and handbooks are available either in the Department's own files or those of the Engineering Societies' Library.

Emergency Motor-Transport Plan

EVERYONE interested in transportation has been wondering what place the motor truck will take in the development of the transportation system of the Nation. Major Brainerd Taylor, of the Quartermaster Department of the United States Army, said at a recent meeting of the Washington Section of the Society that

> If this Country ever again has to face an emergency that threatens to paralyze its industries, its transportation and its everyday life, the United States Army plan for coordinating all available transportation would at least so mitigate conditions that the people of the Country would not suffer for want of food, fuel and other necessities. In the recent railroad-strike situation, the problem called for a solution by highway-transport engineers.

Major Taylor was detailed by the Army to prepare a plan to meet the threatened emergency. One of his fundamental points is that motor transportation can never, either in an emergency or daily commercial practice, replace the long-haul railroad service. It is expected that there will be a thorough discussion of matters bearing on the whole problem at the Automotive Transportation Meeting of the Society at Cleveland in April.

Standards for Roller Bearings

AMONG the many things that the Society of Automotive Engineers is endeavoring to standardize are the dimensions for inch-type tapered-roller bearings, on which a committee has been at work for some time. Ball bearings have been standardized so that the number of sizes available are limited to what is considered essential for the needs of the industries. Work is also progressing on standardizing metric-type roller bearings, a subject of equal importance. In the inch-type tapered-roller bearing field there are now over 200 sizes used in the automotive industry, and it is believed that about 50 sizes would probably care for practically all requirements.

This work is of great importance and, while it is evident as the work of standardization proceeds, that very many differences of opinion will be encountered, there is no doubt that standards can be established that will meet the requirements of all. It may appear at times that too rigid standardization might be unwise and result in a harmful restriction of initiative in the design and development of mechanical devices. Nevertheless, when standardization methods are not too drastic, they will always be found of value to the industry. Great savings in manufacture and in distribution will result, the methods of manufacture can be simplified, the range of sizes that will have to be kept in stock can be reduced, the capital investment of manufacturers and dealers will be less, and the ultimate consumer will be able to buy a standardized product at a price much lower than that of a product where the number of types of sizes made is far in excess of actual needs.—*Machinery.*

Taxing Gasoline Instead of Cars

THERE are important obvious advantages in a gasoline tax to take the place of the annual license-tax for highway purposes. The substitution of a duty on motor-fuel for the present system of vehicle taxation in England has been suggested by representatives of car-owners and dealers and seems to be meeting with much favor. The main feature of the scheme is placing a flat duty per gallon on all imported motor-fuel and abolishing or greatly reducing the present tax per car. It is alleged that a duty of 5d (10 cents) per gal. will produce £10,250,000 ($49,815,000 at normal exchange) revenues in 1924, sufficient to offset the present car-tax, the collections of which are used for highway purposes.

The main argument in favor of the plan is that it would distribute much more equitably than the present system the burden of taxation on motor-car owners. The existing tax, it is pointed out, is the same whether a car travels 400 or 40,000 miles per annum. An owner who has more than one car might pay the full tax on a car used but two or three times during the year. The fuel tax, on the other hand, takes into account automatically the horsepower, the speed and the weight of the vehicle, as well as the mileage. The proposed duty would bear directly on the car-owner in proportion to his use of the road and any evasion of payment would be impossible. Vehicles without internal-combustion engines would continue to be taxed as at present.

Automobile Shows

VARIOUS opinions have been given by men who are prominent in the industry as to the value of the National Automobile Shows that are held at New York City and Chicago each year. The following are some of the large number that are contained in a pamphlet which has recently been issued by the National Automobile Chamber of Commerce.

> The public has come to accept the completeness, size and grandeur of the National shows as a direct expression of one of America's largest and most virile industries.
>
> The shows teach the makers that to see themselves as others see them is not always flattering, but sometimes economical, and always wise.
>
> A show is a business barometer, as well as a guide to the general trend in design and construction.
>
> The material man, the parts-maker, the manufacturer, the dealer, the salesman and the consumer meet at the shows for an exchange of thought.
>
> The shows are forums at which all that the industry has done is brought before the public in the only language that never fails and none can misunderstand, the language of actual performance.
>
> More can be learned in one hour at a show than in a week of visiting the establishments of the makers or by reading any quantity of books or advertising literature.
>
> The shows are the cheapest form of advertising and are therefore effective in reducing the cost of cars.
>
> The shows, with the elaborate publicity campaigns that accompany them, reach a large public group that is not exactly motorwise but keenly interested and forms the nucleus of active "prospects."
>
> A show is advertising backed by personal contact.
>
> We can check our advertising returns from the show, whereas there is no satisfactory check on any other form of advertising.
>
> The newspapers give the shows an amount of space that could by no possibility be purchased or obtained in any other way.
>
> A show is cooperative advertising by the whole industry.
>
> The value of the National Automobile Show is proved by the fact that it is the oldest industrial show that has been in continuous existence in this Country, if not in the world.
>
> The shows are to the manufacturer and the dealer what advance-agents are to the theatrical business.

A New Type of Engineer

CLOSE students of transportation tell us that the motor vehicle is entering an era of unprecedented development as an arm of the national transportation system. It is significant that several great railroad systems have organized departments to study intensively the coordination of motor and rail transport. Of even greater significance is the fact that one or two railroads have actually purchased truck fleets for use at their terminals. Recent joint meetings of Government, transportation and automotive representatives reflected the increased interest in the motor truck, motorbus and motor rail-car as transportation media.

This brings us to the point where a new type of engineer is needed, the motor-transport expert, versed not only in the construction of motor vehicles, but possessing a full knowledge of how they should be operated and maintained to secure from them the maximum of efficiency. Few motor-haulage operations have been lucrative investments; the difference between those companies achieving a substantial profit and the others can generally be traced to the presence or absence of a competent motor-transport engineer. The motor-transport engineer must possess the knowledge of traffic control characteristics of the successful railroad engineer; he must be a judge of good equipment in the form of vehicles, bodies, loading mechanism and repair tools; he must possess the accountant's respect for costs and be able to supervise their accurate compilation. Truly, here is an opportunity for the analytical mind of the engineer.

Predictions are dangerous, but one may be hazarded here. Automotive engineers must turn their attention toward the operating end of the business; the largest percentage of the Nation's motor-transport engineers will be graduates of the automotive industry, particularly from its engineering branch. It seems logical for the Society to become active along automotive transportation lines, especially in exerting its influence to promote an intensive cooperative study of motor-vehicle operation and its problems. The Cleveland Automotive Transportation meeting is the first step in this direction; it will bring together the engineers who design motor trucks, buses and rail-cars, and the motor-transport engineers whose job it is to make them serve at a profit.

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Tendencies in High-Speed Marine-Engine Design

By J. G. VINCENT[1]

MOTORBOAT MEETING PAPER *Illustrated with* DRAWINGS

IN this paper there are discussed the general requirements of a comparatively new type of marine engine, that is, the high-speed type. The need for light weight is discussed and it is pointed out that aircraft-engine design has established a good precedent to follow, particularly with reference to crankshaft, connecting-rod, piston, cylinder and valve design.

Detailed discussion then follows concerning the requirements of this type of engine in respect to cooling, lubrication, starting, idling and general operation. The equipment to be furnished with the engine is covered in a general way and the installation requirements are touched upon.

GASOLINE marine-engine design is apparently entering a new phase of development. It seems that the advances in aircraft-engine construction are primarily responsible for this evolution. Not so many years ago there was a somewhat similar well-defined stage in the progress of marine-engine development, when certain automobile-engine principles were applied with advantage to motorboat engines. The more important of these features were electric-starting and lighting equipment, enclosed valve-mechanism and general improvements tending toward weight reduction and more silent operation. It should not be inferred that marine-engine designers have stood still while other automotive engineers have advanced; this is decidedly not the case. There are many points in connection with marine-powerplant design that are distinctly foreign to other automotive fields and in this paper particular stress will be laid on these problems that have been successfully solved by marine designers.

At present it appears proper to classify gasoline marine-engines under three types; (a) the heavy-duty, slow-speed, (b) the medium-speed, medium-weight and (c) the high-speed, light-weight variety. Although this paper is really intended to cover only the last type it may not be out of place to discuss briefly the requirements that lead to these three essentially different types of engine. Basically, the speed desired of the boat under consideration determines which of the three types of engine is the most suitable and although there is a certain permissible overlapping in the adoption of each type of engine for each service, nevertheless the boundary lines between the slow-speed, the medium-speed and the high-speed engine are pretty clearly defined.

Below 15 m.p.h. the most efficient powerplant for marine service is undoubtedly what is termed the heavy-duty type with an engine speed not exceeding 800 r.p.m. at the very maximum, with 600 r.p.m as a standard to be preferred. Between 15 and 30 m.p.h. the requirements call for a medium-speed engine, turning from about 800 up to about 1200 r.p.m. Above 30 m.p.h. a high-speed engine is demanded, which if direct-connected may be called upon to run as high as 2600 r.p.m. for speeds between 50 and 60 m.p.h.

The demands on a powerplant for high-speed marine service do not differ greatly from the requirements of aircraft usage. In both cases reliability is paramount, light weight very important and economy and smoothness highly desirable. The load characteristics are almost identical, air and water propellers both requiring horsepower varying approximately as the cube of the speed. From this it can be inferred that aircraft engine-design, on which an enormous amount of work has been expended during the last few years, can be used as a basis for the design of this comparatively new type of gasoline marine engine, and this applies particularly to such important elements in the design as the crankshaft, bearing proportions, cylinder construction, valve proportions and cooling arrangements and gas velocities through the passages. This all does not mean, however, that a successful airplane engine can be installed in a boat without any changes in design, and give equally efficient service as in the air. The high-speed marine-engine requires special study in many respects. The more important considerations are outlined under the following headings:

(1) Cooling
(2) Lubrication
(3) Starting
(4) Idling and General Operation
(5) Clutch and Reverse-Gear
(6) Engine Accessories
(7) Accessibility
(8) Direction of Rotation
(9) Installation Requirements

COOLING

Paradoxical as it may seem, the efficient cooling of a marine-engine offers more problems than are met with in other automotive applications of water-cooled internal-combustion engines. While there is an inexhaustible supply of cooling water available, its temperature is considerably below the most efficient operating temperature of the engine and the fact that part of the engine is generally located considerably above the water-level presents another phase of the cooling problem.

The general requirements are best met by a system such as is shown in Fig. 1. The water is taken in from the sea through a scoop suitably located so as to be submerged at all speeds. A shut-off valve is arranged close to the inlet for use when working on piping or connections below the water-line. A check-valve may be installed next in the line to prevent the water discharging back into the sea when the engine is stopped. A gear water-pump is driven from a suitable accessory shaft and, in the installation shown, delivers water to the exhaust-manifold jacket first. The object of this procedure is to raise the temperature of the water more nearly

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to that which will correspond to maximum engine efficiency, a cylinder-jacket outlet water-temperature of 140 to 160 deg. fahr. being desirable. It should be noted that the pump delivers water to the highest point of the exhaust-manifold jacket so that with the engine at rest this part of the system will remain full of water, even should the check-valve mentioned previously be omitted or fail to function. After traversing the length of the exhaust-manifold the water is led from the bottom of the manifold jacket to the bottom of the cylinder jackets through a suitable distributing manifold. The outlets from the cylinder jackets communicate with the inlet-manifold water-jackets, thus giving the benefit of the hottest water available for vaporizing the fuel. After leaving the inlet-manifold jacket the water is either discharged overboard or by-passed back to the pump intake. In certain marine engines, designed by me, a thermostat control has been developed which automatically maintains the correct operating-temperature. As shown on the diagram, a thermostat valve of conventional sylphon construction is mounted in a casing on the intake-manifold jacket and whenever the water temperature rises sufficiently high the bellows expand and open a valve that permits the water to flow overboard. At lower temperatures the water is by-passed back to the pump inlet and, through being recirculated in this manner, becomes warmed-up very quickly, assuring good idling and acceleration. A very important feature of this system is the "pressure"-valve shown in Fig. 1. This is a spring-loaded valve opening toward the pump inlet which prevents the system becoming airbound when starting-up, in case the jackets and piping should not be completely filled with water. It will be understood, of course, that this valve will open only with hydraulic pressure on its under surface so that, if there is any air in the system this air will be first expelled through the bleed shown at *a* in Fig. 1, which passage is normally used to discharge water into the exhaust-pipe for cooling purposes.

With a cooling system as described no manual adjustment or other attention on the part of the pilot or mechanic is required. It is advisable, however, to install a distant-type thermometer in the inlet-manifold jacket as a check on the correct functioning of the system. An addition to the cooling system that in some installations proves desirable consists of the routing of the main sea-water supply through an oil-cooler on its way to the engine pump; such a construction is shown dotted in Fig. 1. This matter will be discussed at greater length under the next heading.

Lubrication

In a high-speed marine engine, as in an aircraft engine, the provision of adequate lubrication to all moving parts is a matter of first importance. Furthermore, in contrast with slower-moving machinery, the lubricating system has the additional duty to perform of carrying away the heat from heavily loaded, high-speed bearings, as well as of serving to cool the interior of the pistons to a moderate extent. Needless to say, good engineering practice dictates full pressure lubrication carried to all crankshaft bearings, with positive lubrication to all camshaft and accessory-drive plain bearings and reliable splash-oiling to all gears, anti-friction bearings and piston-pin bushings. The reverse-gear, when built into an integral extension of the crankcase must also be considered as a part of the engine and continuous lubrication should be provided for all of its bearings, bushings, and gears.

In other respects, however, the lubrication problem is very different on the water from what it is in the air. For instance, means for cooling the oil in aircraft-engine service do not present much difficulty due to the tremendous blast of air available. In fact, in many installations the surfaces of the oil-tank and crankcase are considered ample for the purpose, whereas in other cases a comparatively small oil-radiator is exposed to the slipstream. In marine service no such favorable conditions exist, since there is only a moderate amount of ventilation in the engine compartment and the crankcase itself is thoroughly shielded from what little draft might be available. This practically compels the adoption of a dry sump-system, and adequate provision must be made for cooling the oil in the external oil-tank; this is done best by circulating sea water through suitable cooling-coils immersed in the oil. A typical construction is shown in Fig. 2. In this case all the water used to cool the engine is allowed to flow through the cooling tubes. In other installations a separate scoop is arranged to circulate sea water through the oil-cooler but this does not appear to be as good practice as the system previously described since it entails more piping and joints which are likely to develop leaks. Before passing the subject of oil-cooling, it might be well to state that owing to the relatively low thermal conductivity of oil it is necessary to spread the oil over comparatively large surfaces to get the best results.

Assuming that the lubrication of the engine has been satisfactorily carried out and that adequate oil-cooling means have been provided, there still remains the problem of preventing a surplus of oil reaching the combustion-chamber while the engine is idling or running under light load. This can be accomplished to a certain extent by proper piston and ring design but it also appears desirable in many cases to lower the oil pressure under these conditions. This can be accomplished by either a fixed or an adjustable "bleed" arranged so that at low speeds the capacity of the oil-pump is insufficient to build-up the working pressure, and this simple method has proved very satisfactory in many instances.

The method of "scavenging" the oil from the crankcase and reverse-gear compartment, providing the latter communicates with the former, is somewhat simpler in the high-speed marine engine than in the case of the aircraft engine, since the inclination of the marine engine while operating at high speed seldom exceeds 15 deg. with the bow naturally uppermost, while in the air it is necessary to figure on the steepest climb or the steepest glide possible which at times may reach an angle of 45 deg. or more. This means that for marine service a single scavenging-pump with the inlet located at the rear end of the crankcase will serve to keep the oil-level down so that the connecting-rods will not dip or the oil tend to leak out of the rear bearing.

Starting

The starting of a marine engine of large power presents a problem of more than ordinary difficulty when the various limitations are considered. First, since the high-speed engines under consideration are being developed to obtain the maximum performance for the minimum weight, it follows that the weight of the starting equipment must be kept as low as possible. This implies the necessity for high efficiency on the part of the starting mechanism. The electric starter has proved to possess the necessary qualifications for the task. In the past there has been a tendency to adopt a rather small starting motor geared to run at a very high speed,

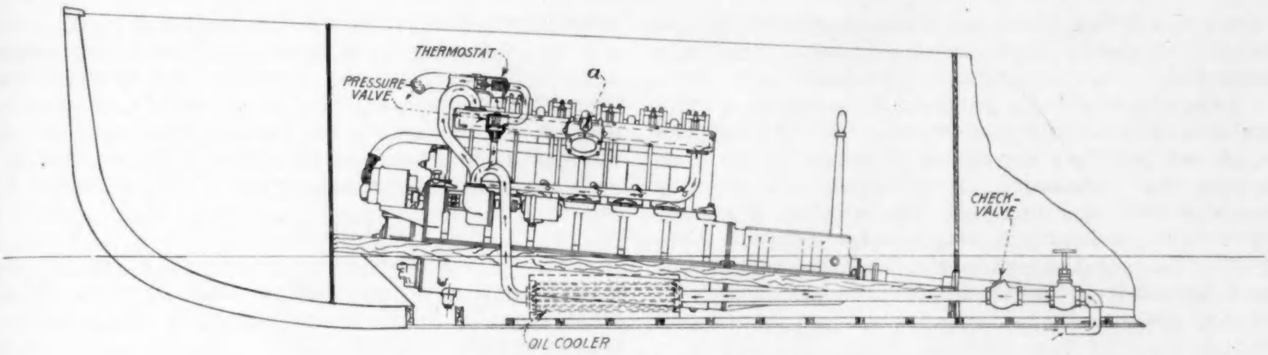


FIG. 1—COOLING SYSTEM FOR A MOTORBOAT ENGINE

which naturally entails a train of gears having more or less irreversible characteristics. The result is that to protect this mechanism from damage in case the engine backfires it is necessary to add some more or less complicated anti-kick device. Therefore, the mechanism becomes unduly complicated and includes some very heavily stressed parts that are subject to failure.

The difficulty encountered with the extremely low-geared electric starters leads to the conclusion that undoubtedly more satisfactory operation can be secured with a starting motor having a considerably higher gear-ratio, such as is normally employed in automobile practice. In other words, instead of a small starting motor geared perhaps 100 to 1, it seems preferable to employ a much larger starting motor geared about 15 or 20 to 1. This, of course, entails the development of larger and more powerful starting motors and somewhat heavier apparatus, but it appears that the demands for the utmost in reliability must offset other considerations.

The failure of the starter to operate should the engine stall while maneuvering in close quarters may lead to a disastrous collision and, similarly, should the starter fail after the engine has been shut-down for any reason in a heavy sea, this may lead to serious consequences. Special stress is laid on these points because undoubtedly starter trouble has been the predominating difficulty experienced with high-speed marine engines.

IDLING AND GENERAL OPERATION

Next in importance to prompt starting of these engines comes the requirement for good idling to assure the boat being under control at all times. This is largely a matter of proper carburetion, although efficient methods of controlling the cylinder lubrication and the jacket-water temperature are contributing factors in obtaining the proper result. The general requirements are very similar to those obtaining with aircraft engines, good acceleration and smooth running at all throttle positions being essential. Although gasoline economy is perhaps not so important considering the weight of fuel that is to be carried, the economic considerations cannot be overlooked. With a high-efficiency engine of the type under consideration it is possible to secure a gasoline consumption as low as 0.53 lb. per b.hp-hr. without resorting to unduly high compression-ratios.

To secure good idling and low-speed operation it is necessary to provide for ample flywheel effect. Unfortunately, in the average boat installation it is not possible to locate a large-diameter flywheel at the rear end of the crankshaft since, due to the inclination of the engine mounting, it is necessary to keep the depth of the engine at this point as small as possible. It is therefore common practice to place the flywheel at the forward end of the crankshaft where usually a fair diameter can be secured. It is desirable from many standpoints to enclose this flywheel; this is not only a matter of securing protection from the revolving flywheel which is usually provided with gear teeth for starting-motor engagement but it is also highly important to prevent the possibility of water that may collect in the bilge from being thrown over the engine by an exposed flywheel. It has frequently happened that in a heavy sea sufficient water was shipped to immerse the flywheel partially, putting the engine out of action through water being thrown into the carbureter and over the ignition system.

It is practically essential to provide a tachometer on an engine of this character. This instrument will fur-

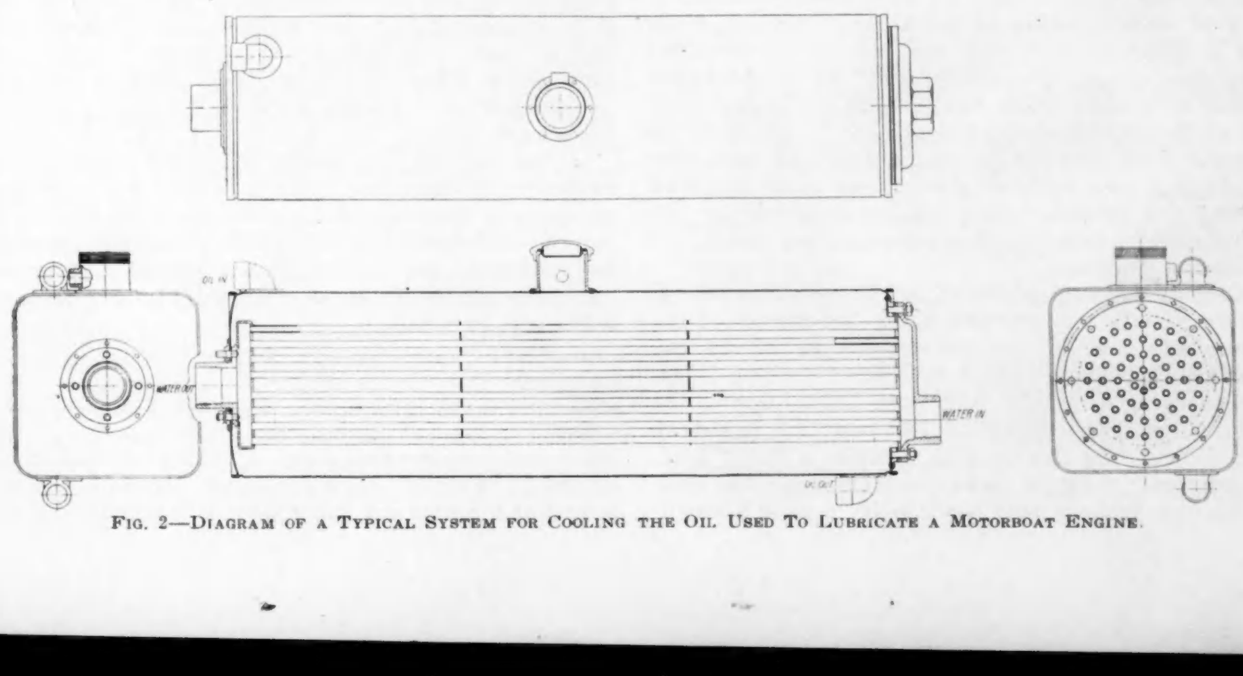


FIG. 2—DIAGRAM OF A TYPICAL SYSTEM FOR COOLING THE OIL USED TO LUBRICATE A MOTORBOAT ENGINE

nish a positive index to the operating conditions of the engine at high speed. A somewhat debatable question is the provision for a governor. In the hands of a thoroughly experienced man, a governor is probably a more or less useless accessory but where twin engines are employed and long cruises are undertaken there is no doubt that the installation of an engine governor is warranted. This is to protect the engine from not merely racing occasionally in rough water but from damaging itself should the clutch slip out of engagement, the propeller-shaft break or the load be removed from any similar cause.

Clutch and Reverse-Gear

The multitude of design problems involved in a suitable marine clutch and reverse-gear have been thoroughly studied in the many years during which the marine-engine has been developed and, aside from possible improvements in materials, there is probably not much room for development. The forward clutch is almost invariably of the toggle-operated multiple-disc type and, excluding perhaps the need for rather frequent adjustment, this can be considered a perfectly satisfactory mechanism. It is also essential to design the clutch so as to minimize the drag in the neutral position so far as possible. The reverse-gear is generally of the planetary type with an external contracting band. Considerable detail study is necessary to make this design thoroughly satisfactory and in the majority of installations the clamping means for the planetary drum are woefully inadequate. This is obviously merely a matter of suitable proportioning of parts made from proper materials and sufficient pressure on the band to provide the necessary braking effect. The lubrication of the clutch and the reverse-gear on the high-speed engine is a matter deserving serious consideration. Although the mechanism revolves as a unit when going ahead there is need for adequate lubrication when in neutral or reverse. If the reverse-gear housing forms a unit with the crankcase, it is good practice to extend the circulation of the engine lubricating system to the reverse-gear. This can be readily accomplished by suitable passages drilled in the crankshaft and in the interior of the reverse-gear. The surplus oil, of course, must be returned to the oil-tank by a suitable suction-tube located in the bottom of the reverse-gear housing and in the majority of installations it is permissible to allow all the return oil from the engine to flow back through this suction-tube so that a single scavenging-pump will be all that is required.

There is some question as to the best method of obtaining a floating connection that should be provided between the engine crankshaft and the reverse-gear drive-shaft; in some cases the crankshaft is positively located while the reverse-gear is allowed to float and assume some fixed position in relation to the propeller-shaft. In any case suitable precautions must be taken to prevent the propeller thrust being absorbed by the crankshaft unless this is contemplated in the design and proper means provided.

The deep-groove radial-type of ball bearing has proved to be very satisfactory for absorbing the thrust of the propeller-shaft, and is undoubtedly preferable to the ordinary ball thrust-type since the radial bearing is capable of carrying a certain radial load in addition to the thrust load from either direction, this resulting in a more compact design. As this bearing sustains a heavy load, careful provision must be made for lubrication and cooling. This can perhaps best be done by casting a downwardly extending trough on the side wall of the reverse-gear housing, this trough carrying the oil that is thrown out from the revolving reverse-gear to the bearing through suitable passages. Means should be provided to prevent the oil-level in the bearing housing from rising too high and suitable packing should be installed to prevent surplus oil from leaking out at the rear end.

Engine Accessories

The accessories to be provided for on high-speed marine engines do not differ materially from those for other types of engines. In regard to the ignition system, it appears that the battery type has certain advantages over the magneto ignition commonly employed in aircraft engines today. This is primarily because a storage-battery must be carried in any event for the starting of the marine engine, whereas this is not the case in airplanes, electric starting having made little headway on aircraft engines. It follows that a generator also is required on a marine engine. It appears that 12 volts represents a good standard for this service. This voltage is suitable also for the running lights of a medium-sized boat but in larger boats, where heavy lighting requirements are met, it is customary and desirable to install an independent lighting outfit that usually develops 32 volts. In these cases it is probably better to divorce the main electrical system from the engine system since the batteries used for lighting would not ordinarily be suitable for the heavy discharge of current required for starting purposes.

Gasoline is usually fed to the carbureter by an air-pressure system and it is therefore necessary that the engine equipment include a small air-pump to develop the 2 or 3-lb. pressure required. While on the subject of the gasoline-feed system it may be well to state that it has become standard practice recently in aircraft engines to abandon the air-pressure system in favor of the gasoline pump preferably of the gear type. However, in a boat the possibility of gasoline leaking into the bilge always presents a very serious menace. In all gasoline pumps, except those of the sylphon type, packing is required around the shaft, which packing requires frequent inspection and adjustment. While touching on the gasoline system it might be well to enter a plea for very generous filter-screens in the gasoline line. Experience has shown that due to condensation and other causes water is very apt to accumulate in the gasoline system of a boat and there is a tendency for a certain amount of rust formation which is very apt to cause stoppage of the carbureter jets. For a similar reason it is advisable to use brass piping for all gasoline lines, and the use of aluminum in carbureters should be discouraged as it has been shown that aluminum carbureters tend to corrode in marine service, this not occurring with brass carbureters.

It has become customary to install remote control-switches for the electric starter since this obviates the necessity of running heavy cables up to the manual starting-switch located near the pilot. With the remote control-system a small push-button serves to operate the remote control-switch by a solenoid and the connecting wires can be small.

Accessibility

Since the high-speed type of marine engine under consideration is used exclusively in fast boats, it follows that engine-room space is, as a rule, very limited as the engine is naturally large in comparison with the overall length of the boat. Furthermore, a boat of this type has,

as a rule, a comparatively narrow beam, so that in many installations the engine pretty completely fills up the compartment provided for it. It is therefore necessary, when designing an engine of this type, to give very careful consideration to the location of the various accessories and other parts of the engine requiring adjustment or inspection. Generally speaking, the Vee-type engine lends itself particularly well to these requirements as it is naturally compact, light in proportion to its power, and, with overhead valves and the carbureters located in the Vee, these more important parts are readily accessible from above.

In discussing accessibility it is natural that the question should be raised as to the merits of hand-holes provided in the crankcase for access to the connecting-rod and main bearings. Heretofore, particularly in the larger and much heavier slow-speed engines, it has been customary to make such provision but the reasons behind this practice do not apply to the class of engine under discussion. For instance, the former type of engine will weigh 15 lb. per hp. and upward, the latter type probably not one-fifth as much. This means that it is a comparatively simple matter to remove the high-speed engine from the boat whenever necessary for major overhauling, and this is a far more satisfactory procedure than attempting to work in the cramped quarters of the engine-room. Furthermore, due to the high-grade material employed, the light reciprocating parts and the excellent lubrication of the high-speed engine, its bearing life is exceptionally long. Again, the engine being designed as compactly as possible, there is little opportunity for providing adequate inspection-openings without sacrificing strength in the crankcase. When it is necessary to give the engine what is termed a "top overhaul," that is, grind the valves, etc., it is usually essential to remove the cylinders, and this of course leaves the crankcase cylinder bores available as inspection openings.

Direction of Rotation

With the powerful high-speed engines used in the many light fast boats at the present time the element of torque reaction has a considerable influence on the steering of the boat and for craft engaged in racing where turns around the course are invariably to the left it is of considerable advantage to have the torque reaction assist in banking the boat on the turns. This means that with a single-screw installation the engine should turn clockwise viewed from the rear, this requiring a right-hand "wheel." Such an engine is also used on the right-hand side of a twin-screw installation, the left-hand engine revolving in the opposite direction. It therefore follows that the right-hand engine, if of the vertical type, should have the exhaust-manifold on the right-hand side and the water outlet on the same side. Similarly the carbureter should be on the left-hand side, together with whatever accessories can be conveniently arranged on that side.

Installation Requirements

It is essential in the design of a high-speed marine engine for the engine designer to work in close harmony with the hull designer to secure the best possible combination of the engine and the hull. The proper distribution of weight in a high-speed boat determines its performance to a large extent and, while individual requirements will vary considerably, there are certain fixed principles that may be laid down. Among the most important is the depth of the crankcase below the center-line of the crankshaft and especially at the rear end it is necessary to keep this dimension down to a minimum; furthermore, a low center of gravity is very desirable. Suitable provision must be made for continuous stringers to support the engine and to avoid weakness, no jogs or recesses should be required in these timbers. Care must be used in locating the oil, water and gasoline connections so that they will be readily accessible in the boat. Standard pipe-threads should be used wherever oil, water and gasoline connections are made to the piping installed in the boat, since this gives the boat-builder the widest latitude in selecting standard fittings for making the required connections.

The engine should be furnished with spark, throttle and mixture controls in such positions as to connect readily with the controls used in the boat. The exhaust-manifold, which is naturally included with the engine equipment, must be designed so that the exhaust-pipe can be connected readily without necessitating any sharp bends adjacent to the manifold. The carbureter should be constructed so that all gasoline leaks due to a flooding carbureter will flow to a common sump that can be connected to a drain-pipe to go overboard. The carbureter air-intake should be carried to a point where a backfire is not likely to set fire to any possible accumulation of gasoline or oil in its neighborhood.

The reverse-gear operating lever should preferably be capable of attachment on either side of the engine to suit different installations. The propeller-shaft coupling should be furnished with the engine and conform to accepted marine standards.

Finally, complete installation drawings should be furnished to the boat-builder, together with a power curve of the engine, recommendations as to maximum speed, diagrammatic layouts of the piping and wiring systems, and requirements in regard to oil and gasoline-tank capacities.

As typical of high-speed marine engines there are appended below complete specifications of both a 6-cylinder and a 12-cylinder engine, the former to develop from 150 to 200 hp., and the latter from 300 to 400 hp., the low rating in each case applying to low-compression engines adapted to run on commercial gasoline, and the higher rating to the same engine equipped with high compression and running on doped fuel for racing purposes.

Bore, in.	5
Stroke, in.	5¼
Displacement, cu. in.	
6 Cylinders	618
12 Cylinders	1,237
Cylinder Arrangement	
6-Cylinder Engine	Vertical in line
12-Cylinder Engine—Two rows of six cylinders, included angle 60 deg.	
Cylinder Construction	Built-up individual steel type
Valve Mechanism	
Single enclosed overhead camshaft over each block of six cylinders	
Valve Actuation	Rocker-arms
Cylinder Center Distance, in.	
6; except between No. 3 and No. 4, 7¼	
Connecting-rods	
9 in. centers, straddle type for 1237-cu. in. engine, I-beam section	
Connecting-rod Bolts	
12-Cylinder Engine, Plain Rod, two 7/16-in. bolts Forked rod, four 5/16-in. bolts	
6-Cylinder Engine, Plain Rod, four 5/16-in. bolts	
Piston Material	Die-Cast Aluminum
Piston-Rings	
Four, concentric type, lower ring below piston-pin, and ground taper	

Piston-pin Diameter, in. 1¼
Piston-pin Bore, in. ⅞
Valves
Number per Cylinder 2
Diameter in the Clear, in. 2
Lift of Inlet-Valve, in. 7/16
Lift of Exhaust-Valve, in. ⅜
Angle of Seat, deg. 30
Valve-Springs
Type Helical
Number per Valve 2
Valve-Timing
Inlet Opens 10 deg. late, closes 45 deg. late
Exhaust Opens 48 deg. early, closes 8 deg. late
Crankshaft
Main Journal Diameter, in. 2⅜
Crankpin Diameter, in. 2⅛
Effective Length of Connecting-Rod Bearing, in. 2 3/16
Effective Length of Intermediate Main Bearings, in. 1 7/16
Effective Length of Center Main Bearing, in. 2 11/16
Crankcase Material
Type
Aluminum Box Section, split on center-line of shaft. The lower half has continuous flanges for bolting to engine timbers and includes reverse-gear housing. The lower halves of the main bearing are carried in the lower half of the crankcase
Ignition
Battery-generator type, consisting of complete two-spark distributor for each set of six cylinders
Water-Pump
Gear type, independent pump for each set of six cylinders
Carbureter
Two duplex 2-in. plain-tube carbureters for 12-cylinder engine; two 2-in. single carbureters for 6-cylinder engine
Oil-Pump
Duplex-gear type, one scavenging-pump, one pressure-pump
Electric Starter
Automatic gearshift with 15 to 1 reduction
Starting Switch
Remote-control type
Generator
Third-Brush regulation, 12 volts
Exhaust-Manifold
Water-Jacketed, built-up sheet-steel type
Water-Temperature Control
Full-Automatic thermostat system
Forward Clutch
Multiple-Disc type, pressure-lubricated, toggle engagement
Reverse-Gear
Planetary type, woven-asbestos lining on brake-band
Thrust Bearing
Deep-groove, radial ball-bearing type
Weight, lb.
6-Cylinder Engine 900
12-Cylinder Engine 1,150
Rating of Six-Cylinder Engine, hp.
5 to 1 Compression-Ratio at 1800 R.P.M. 150
6½ to 1 Compression-Ratio at 2000 R.P.M. 200
Horsepower of 12-cylinder engine is double that of the 6-cylinder engine in each case

It has been attempted in this paper to point out that the tremendous increase in speed of displacement boats has created a need for a new type of marine engine. It is believed that the requirements of the service have been pointed out sufficiently well to make a convincing argument in favor of the special light construction described as compared with the heavy construction used heretofore in slower-speed marine engines. There are undoubtedly a number of valuable lessons to be drawn from aircraft-engine design and in many respects the materials used and the method of design will be identical in both cases. In other respects the requirements of marine service differ from other automotive practice and there is plenty of room for the marine designer to show his ingenuity.

FEBRUARY COUNCIL MEETING

THE meeting of the Council held in New York on Feb. 26 was attended by President Alden, First Vice-President Crane, Vice-Presidents Warner and Masury, Past-President Bachman and Councilor Scott.

The financial statement as of Jan. 31, 1923, showed a net balance of assets over liabilities of $120,404.54, this being $10,229.22 less than the corresponding figure on the same day of 1922. The income of the Society for the first 4 months of the current fiscal year amounted to $91,950.59. The operating expense during the first 4 months of the current fiscal year was $93,532.15.

Fifty-seven applications for individual membership and ten for student enrollment were approved. The following transfers in grade of membership were made: From Associate to Member, E. W. Kimball, G. L. Crosby, C. S. Price; Foreign Member to Member, Charles A. Bennet, E. N. Rahusen, Wallace M. Van Deusen; Service Member to Member, Gordon R. Pennington; Member to Service Member, J. H. Geisse; Junior to Member, Erwin L. Bare, Louis C. Huck, John F. Wyzalek, W. E. Shively; Junior to Associate, M. Lair Hull.

It was reported that up to Feb. 26, 1923, 165 applications for membership had been received during 1923, as compared with 113 received during the first 2 months of 1922, and 136 during the first 2 months of 1921.

The following appointments to the Standards Committee were made:

C. A. Carlson	Motorboat Division
F. W. Davis	Truck Division
L. R. Buckendale	Axle and Wheels Division
H. L. Williams	Iron and Steel Division
E. W. Ehn	Iron and Steel Division

It was decided not to assign the subject of tire-chain clearances for consideration in connection with the standardization activities of the Society.

Walter F. Graham was appointed to serve as the Society's representative on the American Society for Testing Materials Committee on Malleable Irons.

R. E. Brown was appointed by President Alden to serve as the Society's representative on the Consulting Committee on Lumber Standardization, City of Washington.

T. J. Litle, Jr., was designated a member of the Research Committee.

A. L. Riker was appointed a member of the Highways Committee.

The next meeting of the Council was tentatively scheduled to be held in Cleveland on April 25, the day preceding the opening of the Society's Automotive Transportation Meeting which will continue until April 28.

Immediate Possibilities of Commercial Airplane Service

By C. G. Peterson[1]

Annual Meeting Paper

STATING that the heretofore impassable barriers to commercial aviation have been costs and the lack of desire of the public to fly often, or to fly at all, the author proposes that the public, which must constitute the market for airplanes on a commercial basis, be educated by a demonstration of safe and reliable pay-load airplane-service extended over an indefinite period, and outlines a plan that includes the surmounting of cost deterrents.

He marshals arguments and statistics to show that such a public demonstration can be made by a proper and adequate equipment, operation and maintenance of the Aerial Mail Service, since it has been demonstrated already by this service that mail can be carried safely by air and that it can be flown through hard Northern winter weather. His statistics include a consideration of the present volume of mail, special-delivery-letter and parcel or package-carrying possibilities as revenue producers, being inclusive also of the postal rates necessary under such conditions.

An estimate on the cost of equipping and operating a night-flying line between New York City and Chicago, based on present equipment, is given. The author believes that passenger traffic would follow unsolicited just as soon as the public realized that the mail airplanes were flying safely and on-time.

THIS meeting is to be devoted to a discussion of the design of commercial airplanes. What are they, and what will they be used for? Let us consider first a few unpleasant facts; then I will point out how commercial airplanes can be used and what they will be used for. We are entering the fifth year after the war, in what had been predicted to be the age of commercial aviation. But during these years not one American company that I know of has sold a single commercial airplane in the United States at a price to meet the construction cost of the airplane, the engine, and its accessories. To be sure, some new airplanes have been built and have been sold, but they have been equipped with wartime engines. Some new engines have been sold, but they have not often been placed in new airplanes. Sales of completely new equipment, airplane, engines, instruments, propellers, and accessories, sold as a complete unit, and all above the cost of production, are unheard of for commercial work. We read of and see companies and individual flyers carrying passengers, but what company in America could afford to carry passengers if it had to pay the first cost of the airplanes and the engines. The Army patrols portions of the forests for fire protection, but no new airplanes have been sold to it or to individuals for that purpose. The Navy has done large-scale mapping, but neither the Navy nor civilians are buying new flying equipment for that purpose. The Post Office Department flies some mail, but has its own shops for rebuilding wartime DeHaviland airplanes and Liberty engines. The most discussed fields for commercial aviation are passenger carrying, photography, forest patrol and the transportation of mail and express. If in 5 years not a single complete American airplane has been sold above first cost for these purposes, for what commercial purpose shall we design either commercial airplanes or engines? We must find a market that can afford to purchase new equipment before we can design for that market.

Thus far, I believe we all shall agree that the impassable barriers to commercial aviation have been the cost and the lack of desire on the part of the public to fly often or at all. If we spread the cost very thin, and do not ask strangers to fly, does not the prospect look brighter? There is such a market ready and waiting, a market that will buy airplanes and engines eagerly as soon as they are proved to be better than the existing types. In this market any notable improvement that will increase the durability, economy or safety will find a ready sale. The requirements will be set forth so clearly that designers will be relieved from the present impossible situation of designing something for which there is no use or no sale. This market needs only to be told the story plainly and it will be sold, sold for all time, and will stay sold. This market is the people of the United States as represented in the biggest business on earth, the United States mail.

What the Aerial Mail Has Demonstrated

Facts and figures to prove this are abundant. The industry is immeasurably indebted to Congress for a continuance, during the last 4 years, of appropriations that have allowed the demonstration in an experimental way of two essential facts; that mail can be carried safely by air, and that it can be flown through winter weather in the North. This demonstration has been on a sufficiently large scale so that these facts cannot be disputed, in Congress or elsewhere. Another fact is the volume of mail to be carried, millions of letters daily that require no drumming-up of business. Still another is that the millions of special-delivery stamps sold yearly demonstrate that thousands of people are always in a great hurry to have their mail delivered, even though they know that special delivery means a saving of a very short time at the delivery end only. The volume of telegrams and night letters further proves this.

Here are more facts that have an important bearing. Carrying parcels by post costs millions of dollars more than the revenue received from postage, yet it was eagerly adopted and never will be discontinued. It costs more to deliver rural free-delivery mail from the local postoffice to the patron than the entire revenue developed at the point of origin amounts to, but who believes the rural free-delivery will be discontinued? As a final fact, the people, through their representatives in Congress, have been willing for decades to take a loss in carrying mail. This year it is predicted that the cost of the Post Office Department will exceed the revenue by about $60,-000,000. If by air mail days can be saved instead of hours, if the revenue of the Post Office Department can

[1] Assistant to the president, Wright Aeronautical Corporation, Paterson, N. J.

be greatly increased and the operating deficit not materially increased, will more facts be required to get a market for our designers?

Let us scan some figures to substantiate these facts. Every day there is mailed in New York City for delivery in Chicago an average of 160,000 letters. But this, by no means, represents the full amount of first-class mail sent daily from New York City to Chicago. The average amount, I have been told, is about 25 tons, which is the equivalent of 2,000,000 letters per day, the difference representing gateway mail at both points and mail matter other than letters. Most of this mail leaves New York City after 5 p. m., and cannot be delivered under 30 hr. after the train leaves New York City, much of it being over 41 hr. on the way. To beat this time and to save a whole business day, New York City-Chicago mail must be flown all or part of the way at night. With proper beacon-lights and properly lighted emergency fields at, say, 20-mile intervals, with radio on the airplanes and radio-direction-finders on the ground, night-flying is possible.

We have prepared extensive estimates on the cost of equipping and operating a night-flying line from New York City to Chicago, based on the present known flying equipment, with the contractor providing his own fields, radio and lights. For four airplanes each way daily the cost will be less than $2,000,000 per year. These four airplanes would handle about 100,000,000 letters per year if they were carried all the way by air, or twice that number if carried part way by train and part way by air. But it is safe to assume that 150,000,000 letters per year between these two cities could be expedited 1 business day at a gross cost of $2,000,000, or about 1⅓ cents per letter. The Post Office Department estimates the present cost of handling a letter at about 1 cent; therefore, if the present cost of 1 cent were added to the air-transmittal cost of 1⅓ cents, the cost to the Government above the 2-cent rate would be only ⅓ cent per letter and the total cost to the Government would be only $500,000. It has been proposed by the Post Office Committee, for very good reasons, to charge a 6-cent rate for air mail and to make up the rest of the load with regular-rate mail matter. On this 6-cent rate there would be a profit to the Government of 3⅔ cents per letter; and 44,000 of these air stamps sold per day would yield sufficient profit to offset the $500,000 cost per year. Forty-four thousand letters are only about 2 per cent of the mail carried at present on this route. To prevent misunderstanding, let me repeat that this cost is based on four airplanes daily each way and a 4-year contract. The cost cannot exceed $500,000 and may be nothing. With two airplanes daily the cost would be about $1,500,000; with one airplane about $1,000,000 per year. The authorized rate to be paid to the contractor if such a thing were necessary, should be sufficient to cover the latter case, or 5 cents per cu. ft. of mail compartment space per mile. I do not think it would be necessary for Congress to specify a maximum or a minimum rate, because it has not done so in the appropriation for expediting foreign mail by air. It will be remembered that for years $150,000 per year has been appropriated for expediting foreign mail by air with no limit as to the rate.

The Effect on the Designer

This is where the rate begins to affect the designer. It probably would take 60 airplanes and 80 engines to cover the four-airplane route, as described above. Based on a 1000-hr. life, the airplanes would be worn-out in less than 3 years; so there would be a steady market for 20 airplanes and 27 engines per year on this one run. It is certain that if the New York City-Chicago route were established, other lines would be demanded and provided. The first extensions, perhaps, would be to St. Paul, Omaha, Kansas City and St. Louis, because all these cities could get the mail from New York City the day after it was posted, and would save 1 or 2 business days. Other probable routes would be two lines to the Pacific coast, one north-and-south line east of the Rocky Mountains, one from Chicago to New Orleans and one each on the Atlantic and the Pacific coasts. The total mileage might soon reach 15,000 miles, which would require from 500 to 600 airplanes, with a heavy yearly replacement of both airplanes and engines.

The design of airplanes for carrying mail from New York City to Chicago should be predicated on a mail-load of at least 1000 lb., a maximum speed of 125 m.p.h., and an economical cruising-speed of 100 m.p.h., with a fuel-capacity for not less than 350 miles. Forty letters weigh about 1 lb. and 1 cu. ft. of mail weighs about 25 lb., so that considerable weather-proofed cockpit space must be provided in a location that is free from fire hazard. A twin-engine airplane designed to fly well with one engine would, undoubtedly, be much more valuable for night-flying than a single-engine airplane. One such airplane was almost completed in Germany before work on it was ordered stopped by the Allied Commission. The improved vision of a twin-engine airplane, in that the pilot does not need to look through a propeller, almost equals in importance the added safety of such an airplane.

Passenger traffic would follow unsolicited as soon as the communities realized that the airplanes were flying safely and on-time. There would be little need of providing passenger space in mail airplanes, other than room for one passenger, perhaps, and that need not be made more comfortable than the pilot's seat. Mail airplanes will usually be loaded to their full capacity with mail and will leave at times and from places that may not be convenient for passengers. When passenger business comes, airplanes can be designed for it, but they will be as different from mail airplanes as Pullman cars are different from railway post-office cars.

Congress will not take action on this matter this term because of press of business. But at the next session plans should be made so that the matter can be presented clearly and forcefully. Not less important will be the presenting of facts to the people at large, so that they can understand what it will mean to them individually. So far as commercial aviation goes we have run round in circles for nearly 5 years. Here is a straight course. When the time comes to act, let us be able to depend on your support and efforts.

Service and Its Relation to the Industry

By Otis C. Funderburk[1]

Chicago Service Meeting Paper *Illustrated with* Drawings and Photograrhs

AFTER outlining the ideas regarding the success of a service-station which the author had when he entered the service industry, such as a convenient location and consistent newspaper advertising, the 24-hr. service that his organization is prepared to furnish for Ford cars is described briefly. The methods employed in getting service work on Lincoln cars by the use of circular and personal letters are commented on briefly, it being pointed out that January and February are now two of the best months in the year as regards the amount of service work performed instead of being dull. The importance of a modern tool-equipment and the careful selection of the personnel for a service-station are mentioned, emphasis being laid upon the fact that in a service organization the men should have a fundamental education for their work.

A number of pieces of special equipment that have been purchased from outside manufacturers or developed by the author's own organization are illustrated and described. Among the latter are an inclined platform for raising the front end of the car when work has to be done on the engine from underneath, a special spark-synchronizing device and a rig for relining brakes. The importance of having a thoroughly competent floor-man to meet the customer and write the repair order is emphasized; and a brief description of the method of handling work in the shop is given together with an outline of the road-test that is made of all jobs that necessitate any change in the running-gear of the engine. The importance of delivering the car to the owner on time, clean and free from tool-marks is pointed out.

The flat-rate system of service charges receives consideration, the author being of the opinion that eventually practically all maintenance work will be handled on that basis. The way in which the flat rates charged by his service-station were arrived at are outlined briefly. An indication of the way in which cost data on an operation are secured and distributed among the various accounts completes the paper.

SERVICE is to the automobile business what safety-vaults are to the banker. Both are essential to the security of the business. Today we have graduated the industry into the greater realm known as "transportation service." This embraces rail, electric and steamer lines and motor cars and trucks. The motor car is now sold as much by the satisfactory reputation of the service-station of the dealer as by the efforts of the sales force. One of the first questions asked by a prospective customer is, "What kind of service do you give?" Service should be founded upon a mutual understanding based on honesty.

When we started our business we had certain ideas which have proved successful. First was a convenient location. We therefore built upon a corner of the most prominent thoroughfare in Boston, Commonwealth Avenue, which is in the heart of the automobile district. It was more costly but it has more than repaid us in advertising value, as well as proved a great aid in sales and service. Our firm was made up of practical executives who had had extensive experience in dealing with owners of high-grade motor cars, and we aimed to make service an asset and not a liability. From the start we were firm believers in advertising and used the newspapers consistently. We made an analysis of circulations. Our new building was fitted up so that it was not outranked by any other in the city. An electric sign on the roof that could be seen for miles in all directions flashed the name Lincoln every few seconds. It now flashes both Lincoln and Ford names and the fact that we give 24-hr. service on Ford cars.

We decided to follow right through with the owner in a service way from the very day he took delivery of his car, our first step in this direction being to attach a small tag to the instrument-board regarding the changing of oil and grease, the care of the battery, etc. In view of the fact that we had a new account we felt that a large proportion of our service work at first would come as a result of accidents to customers' cars. Our plan for taking care of cars that have been in collisions is efficient without involving brass-band methods. Instead of a service-vehicle painted in bright hue, with machinery and tackle like those on a wrecking train on a railroad, we send out two cars. The owner with his family transfers into the first one and goes away from an embarrassing predicament, and the wrecked car is towed quickly and quietly to the service-station. We have found that our owners appreciate this spirit of cooperation on our part.

24-Hr. Service on Ford Cars

When we took on the Ford account we inaugurated our 24-hr. service for Ford cars. This has proved very successful. Owners of fleets, especially, realize how much it means to know that they may have any disabled car brought in at night for repairs, and have it back on the job the next day unless too badly damaged to make this possible. This has not only brought us much service work but also many sales. The police departments of a number of the cities and towns adjoining Boston now telephone us when a car is disabled or abandoned and ask us to come out and remove it from the highway, no matter what make of car it may be. We find now that five men can operate the night shift. In an emergency they can make up two wrecking-crews, leaving one man in charge of the shop; and when not on the road they can take care of an extremely large amount of repair work. The percentage of towing jobs are 35 per cent at night and 65 per cent by day.

Our method of getting work into our shop has, perhaps, been rather unusual, especially in connection with the Ford service. Shortly after we started handling Ford cars, we made an investigation and found that we were not getting much repair-work, this being due to the fact that the Ford business in and around Boston is extremely well organized and it is rather difficult for a new-comer to break into the service work. We therefore secured a list of Ford owners in greater Boston and to some 25,000 of these we issued a card very similar to that given by a club to a member. The owner's

[1] President and treasurer, Funderburk & Mitchell, Inc., Boston.

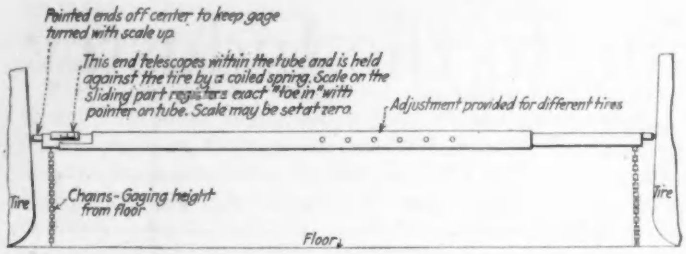


FIG. 1—FRONT-WHEEL GAGE THAT IS ADJUSTABLE FOR VARIOUS SIZES OF TIRE

name was written on the card which stated that he was entitled to inspection and adjustment of the ignition system on his car at 30-day intervals, for which no labor charge would be made. On one side of the card was an illustration of our building, the 24-hr. service being featured. Above this engraving was a place for entering the dates of inspection. The results were surprising. Many Ford owners called to look our building over, some coming at night because that was their only available time. Very soon the word went around that here was a place to get something done at any time and gratis if warranted. To give actual figures, an average of 25 owners a day called at our Ford repair-department in the first two months. Many asked questions about ignition which were answered courteously and thoroughly. A large number bought coil-points, generator cut-outs, timer parts and similar supplies. Most of them are now permanent customers. We have sold 30 or 35 new Ford cars in this way; and all of these sales will aid us in building up our Ford business.

In connection with getting service work on Lincoln cars, we have kept in touch with our owners by circular and personal letters. About the middle of October, we send out a circular letter stating the percentage of alcohol to obtain a proper anti-freeze solution and advising owners what our charge will be for it. When the tail-lamp regulation went into effect in Massachusetts we went to the trouble of having a specially designed bracket made to attach a high-grade tail-lamp to Lincoln cars. We then sent out a circular letter to all Lincoln owners, and as a result attached tail-lamps to approximately 80 per cent of the Lincoln cars in Massachusetts, despite the fact that some 30 or 35 lights were being marketed at a lower price than the one which we offered. This was striking evidence of the fact that owners of high-grade cars are not penurious when it comes to buying something really good for their cars. About the middle of December, we send out a circular letter to all our owners telling them that the best time has arrived for overhauling and repainting their cars. This enables us to get in a large amount of work during the period which is usually dull, and, due to the good profit in repaint work, January and February stand out as two of the best months in the year as regards the amount of service work performed. As we have no paintshop of our own we job the work out to two or three shops near by at wholesale prices. When we notice on a customer's service card that he has not had his car in the shop for some time, we either write him a letter or get in touch with him personally to find out if he is dissatisfied. This is very rare, however, as upon the completion of a service job we usually write the owner asking him if the work has been performed satisfactorily and if he has any comments to make. If there are any criticisms or misunderstandings they are straightened out without delay.

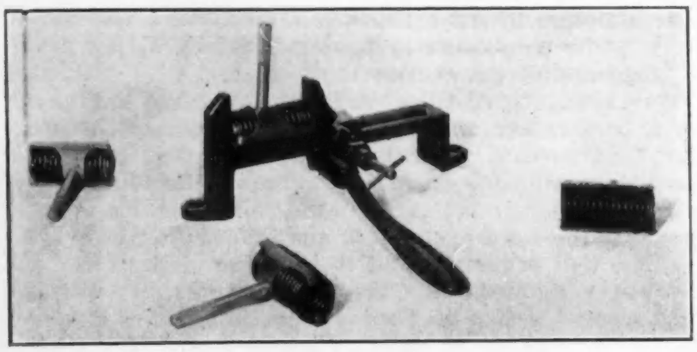


FIG. 2—DEVICE FOR COMPRESSING VALVE-SPRINGS

MODERN EQUIPMENT AND TRAINED PERSONNEL NECESSARY

After getting the work into the shop, it is up to us to see that it is performed in accordance with our policies as set forth in the preceding paragraphs. This means that our equipment must be thoroughly modern and that our workmen must be efficient and well-trained. Of course, the small dealer in the little town cannot carry 100 per cent tools and machinery, but he should be sold on the idea that no chain is stronger than its weakest link; that slipshod methods in the smaller towns eventually will reflect upon the distributor, and through him on the maker, thereby lessening sales at a cost to all concerned. The distributor should keep in close touch with the outside dealers to aid them when service problems come up; not in a patronizing way, but with a spirit of cooperation. The small dealer may be able to give the distributor ideas; coordination will build up the entire organization. When the service everywhere, or nearly everywhere, is uniformly good it becomes known to each owner through other owners, and the owner then begins to take an interest in his car, so that the chauffeur will not be allowed to take a car to some friend to have it repaired. It is one of the best methods to get the work inside your doors.

The personnel should be selected carefully. It cannot be done in a week or a month. In our organization we have been building up the personnel from the start. We treat our men in such a manner as to give them a feeling of trust and confidence. We do not jump on them when they make a mistake. They have been taught to know that mistakes are costly; that they may be avoided by using common-sense and judgment; that it is better to prevent them at the start. So our workers are not afraid to ask questions or let some one know they are puzzled by a certain bit of work. This has been brought about by asking men to rectify mistakes they have made by working at night without pay. They have agreed that this is fair and do it without grumbling. But the men learned their lessons so long ago that we have minimized mistakes now. This has resulted in eliminating that bugbear of service departments, concealed mistakes.

This is the age of specialists. Therefore, in a service organization the men should have a fundamental education for their work. On our ignition jobs we put men who have been educated in the underlying principles of electricity. Other men do all their work on transmissions. Various other parts of the car are taken care of by men who have developed for just those things. This leads to efficiency. When the ignition man has a magneto to take down, being skilled, he goes to the tool-rack and picks out proper wrenches, screw-drivers and other tools needed for the job. The unskilled man takes a couple offhand, goes back to his bench and tries them; they may not fit, and he makes a second, third or fourth

trip, mentally guessing what he needs. That means just so much more time that the owner is paying for; waste time in getting the repairs done as specified. The same applies to other jobs. In our service department we have overcome this through talks to the men, and also by having experts come in to show what can be done through systematic effort. The results accomplished in this way have been extremely satisfactory as the men take pride in the efficiency with which they do their work.

It is a fact that work cannot be efficiently done without the proper tools. The manufacture of labor-saving devices for automotive work has become a complete industry in itself. There is no excuse for any service-shop trying to get along without the proper equipment. For a small extra charge we had a representative of a large socket-wrench firm call and design wrenches for us that would fit the various jobs. For instance, they furnished a double-end Ell wrench that fits both the cylinder-head and the intake-manifold nuts. This type of wrench which cuts down the number of tools a worker has on the job is invaluable as a time-saver, yet its cost is trifling. Precision tools also have become familiar to us and are a necessity. Pistons, crankshafts and cylinders cannot be properly inspected without micrometers. Crankshafts or connecting-rod bearings cannot be tested for eccentricity without an indicator gage and the proper clamps for holding it in the various places of application. This sort of equipment assists a worker in immediately locating the source of trouble. How could the noise in a tappet due to a flat spot in a cam roller be located without accurate measuring devices? Builders of motor cars generally are able to supply the service-man with a good line of special wrenches, pullers and other tools which are of great value.

Some Special Equipment

Out of all the various duplications of devices by different manufacturers, there is generally one that appears to be so much better as to make the sales success of any of the others seem a mystery. Such a device is a front-wheel gage illustrated in Fig. 1 which is manufactured near Boston by a small company. The ingenious manner in which the complicated process is performed accurately has made this gage very popular with local service-men. When this gage is in use it is placed between the front wheels on the forward side of the axle with the pointed ends bearing against the tires and the pendant chains with their ends just touching the floor. Both ends are telescopic, one being adjusted and set for the various sizes of tire and the other being forced outward by a coil spring inside the bar. The tension of this spring and the pointed ends are sufficient to hold the gage in position. The sliding end carries a graduated scale that is adjustable and can be set at zero after the gage is in place. The pointed ends being off center, the scale is always on the upper side where it can be easily seen. After this gage is in place the car is rolled forward until the gage is behind the axle and the chains again have their ends just touching the floor. The toe-in is then read from the scale. This reading is accurate regardless of irregularities in tire mounting and untrue wheels because the gage is not moved between readings.

Another device that is a great time-saver and makes a dangerous operation safe for the worker is the valve-spring compressor that is illustrated in Fig. 2. Everyone who has worked on engines has a dread of placing a valve-spring in a vise together with two little blocks and then fitting a pair of clips to hold it while putting it in position. The equipment pictured here compresses the

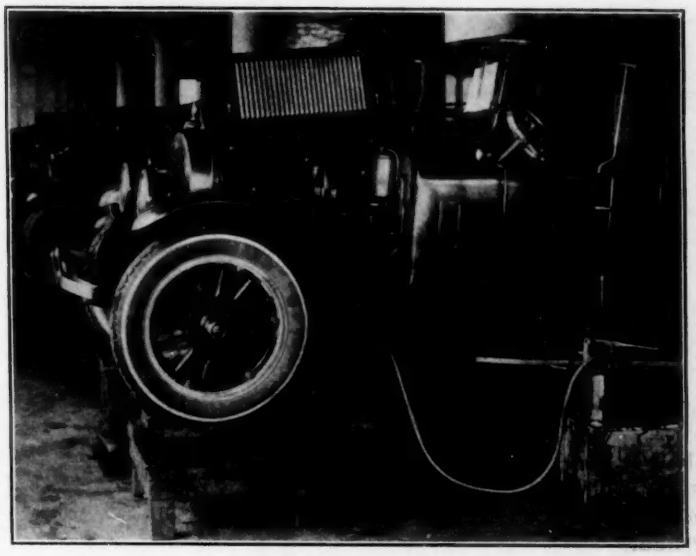


Fig. 3—One of the Inclined Platforms That Has Been Developed To Raise One End of a Car Clear of the Floor and Permit a Man to Work Underneath

spring with an ingenious lever and toggle arrangement and the double clip with the handle is absolutely safe against slipping. Complete sets of these clips on the job eliminate unnecessary trips by the mechanic between the car and the spring compressor which is screwed to the bench. This rigging has found great favor with our mechanics.

In Fig. 3 will be noticed a large floor-type Alemite gun. With the use of this gun we are able to grease a car in less than half the time necessary with a hand-gun. Referring to the photograph, a stroke of the lever, which is seen in a horizontal position on top of the container, forces into the part to be lubricated ½ cu. in. or so of grease under pressure as high as 2500 lb. Additional pressure is applied only on the lever and is not stored up in any way. This is a great advantage over the screw type of hand-gun that must first be screwed up to apply

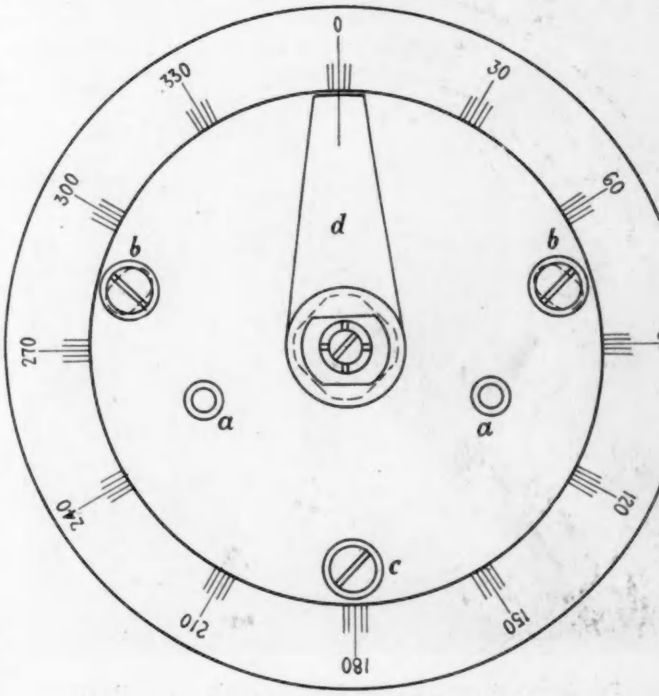


Fig. 4—Diagram of the Spark-Synchronizing Device

the pressure and then unscrewed before disconnecting the hose.

We maintain a small engineering office in which development and advancement work is carried on. When the need of some device is felt and there is nothing in the market to cover the work, equipment designed to meet the approval of those concerned is built. Such a product is the spark synchronizing device for the Delco ignition system on a Lincoln car which is arranged with a separate breaker for each bank of four cylinders. One of the adjustments which is most important to the performance of the car and one of the most difficult to make exactly right is the synchronizing of these two breakers. The spark must have exactly the same advance in both sides of the engine. Referring to the diagram that is reproduced in Fig. 4, the breakers are located on the posts at *a* which are fastened to the base plate. The base plate in turn is fastened to the distributor main casting with three screws. These screws at *b* pass through a slot in the plate that permits the whole plate assembly to oscillate about the third screw at *c*. This oscillation changes the angular relation of the two breakers and permits of an accurate synchronization. Our method of making this adjustment is very simple and very accurate. After removing the distributor head and rotor the pointer shown at *d* is slipped over the cam and a pencil mark on the distributor casting is made opposite the pointer wherever it should happen to be. The protractor, which has a pilot on the under side fitting the casting bore, is laid in position on top of the distributor casting and the screw that spreads the shaft inside the cam is loosened. The pointer may now be revolved freely about the shaft without turning the engine over. A small light on a dry-cell circuit is wired to each breaker so

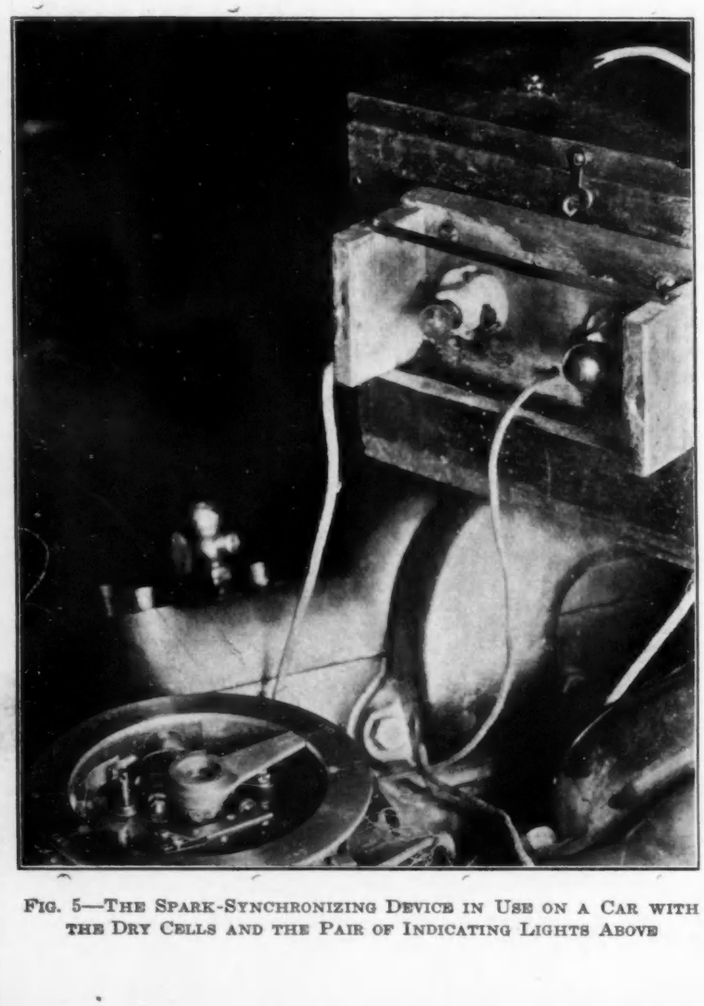


FIG. 5—THE SPARK-SYNCHRONIZING DEVICE IN USE ON A CAR WITH THE DRY CELLS AND THE PAIR OF INDICATING LIGHTS ABOVE

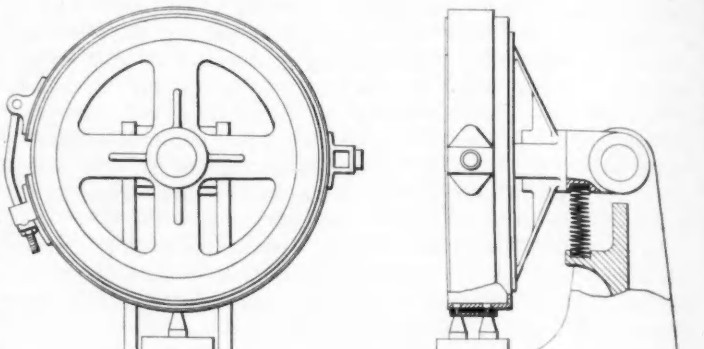


FIG. 6—JIG FOR RELINING BRAKES

that the light goes out when the contacts break. The Lincoln cylinders being spaced on an included angle of 60 deg. the pointer should travel 30 deg. from the first spark to the second and 60 deg. from the second to the third. The protractor is graduated every 30 deg. and shows the permissible tolerance of 2 deg. in either direction. We find that if the points are smooth and the gap properly adjusted and the break occurs within the tolerance but not exactly on the exact point it can be corrected by slightly adjusting the gap but if the break occurs more than 2 deg. off it is necessary to change the position of the plate. It will be noticed that this is also a check on the workmanship of the cam and makes it possible to set these breakers to give the best results in all eight cylinders, in place of adjusting from two adjacent cylinder markings on the flywheel. After this adjustment is made the cam set-screw is tightened, locating the pointer from the pencil mark on the casting, and the distributor is reassembled. The use of this device is obviously a great time-saver over the old method of taking up the floor and the clutch cover and adjusting from the marks on the flywheel while turning the engine over by hand. It is also seen that it is vastly more accurate when account is taken of the lag in the timing chain and of the tolerances adding up in the many parts that form the drive between the crankshaft and the distributor. Fig. 5 shows the general layout of this device, the wooden box carrying the dry cells and the pair of small lights in their protecting cage.

Relining brakes has always been a mean job. It is very difficult to hold at one time the band, the lining, the small rivet and the punch. This process is common enough to merit a business-like and efficient rig. The sketch reproduced in Fig. 6 shows the stand that is bolted to the bench and the method of mounting a brake-drum on a shaft so that it can be turned about its center and also raised off the dies. The band and the new lining are placed on the outside of the drum and tightened into place. A ½-in. hole located at each rivet in the drum permits all the holes in the new lining to be drilled at one time. The tubular rivets, which we have found entirely satisfactory, are all pushed into place and then riveted from the inside of the drum, through the series of holes, using the dies to hold the rivet-head. The coiled spring is adjusted so that it is capable of just balancing the weight of the drum assembly. The weight of the punch in the worker's hand easily holds the rivets down to the dies but, upon releasing, the coiled spring forces it up to a position where all the irregularities on the band clear the die and the drum can be revolved on its shaft. This method has worked out very well and made it possible to reline a brake in less than one-half the time consumed when using a vise.

We have found that chain-falls mounted on a rail are far in advance of any portable jacks and hoists. They can be used for removing the body, the engine or the rear end. We hoist the front end of the engine for timing work in place of jacking up from underneath. It is necessary, however, when doing piston or bearing work from the underside to have the car very steady. The swinging resulting from chain-falls retards the use of indicator gages and other measuring tools. For this work we made up the inclined platforms shown in Fig. 3. They are of exactly the right height to permit a man to work comfortably on a floor-creeper and yet they in no way inconvenience him. The car can be driven on and off of these platforms without difficulty.

We have always instructed our men to be very careful not to mar or spot the cars. The photograph reproduced in Fig. 7 shows how carefully cars are covered while they are in the shop. Note that even the steering-wheel and the front frame-bar are enclosed in leather wrappings. The men are furnished with clean overalls daily.

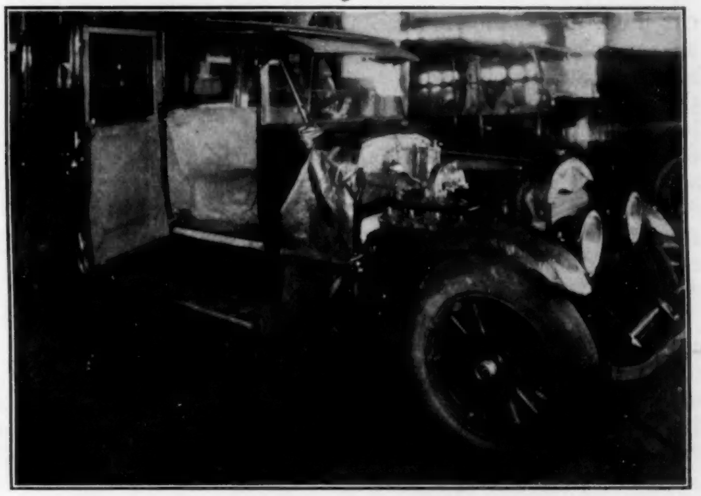
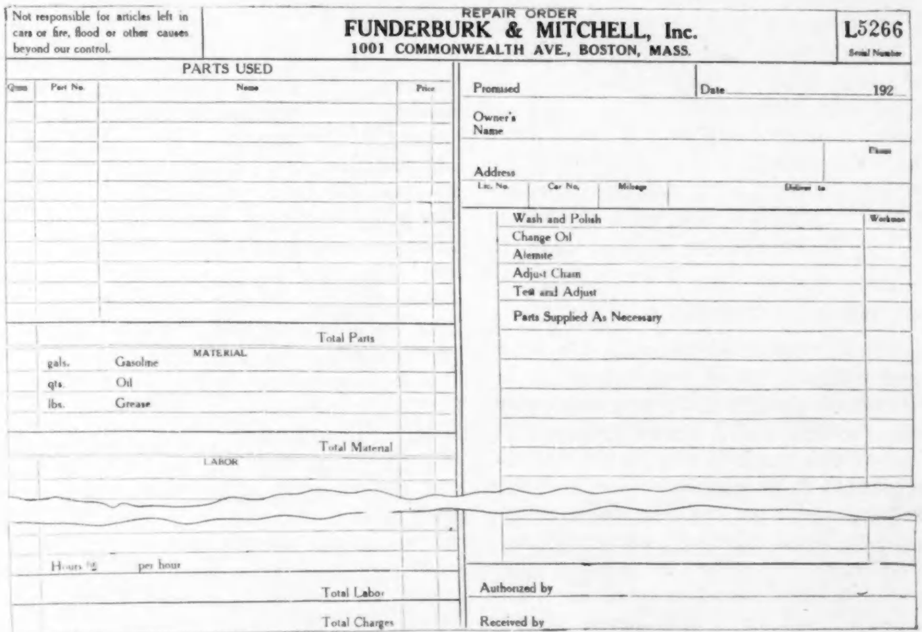


Fig. 7—How Cars Are Covered while They Are in the Shop



Not responsible for articles left in cars or fire, flood or other causes beyond our control.

REPAIR ORDER
FUNDERBURK & MITCHELL, Inc.
1001 COMMONWEALTH AVE., BOSTON, MASS.

L5266
Serial Number

PARTS USED

Quan | Part No. | Name | Price

Total Parts

MATERIAL

gals. Gasoline
qts. Oil
lbs. Grease

Total Material

LABOR

Hours @ $ per hour

Total Labor

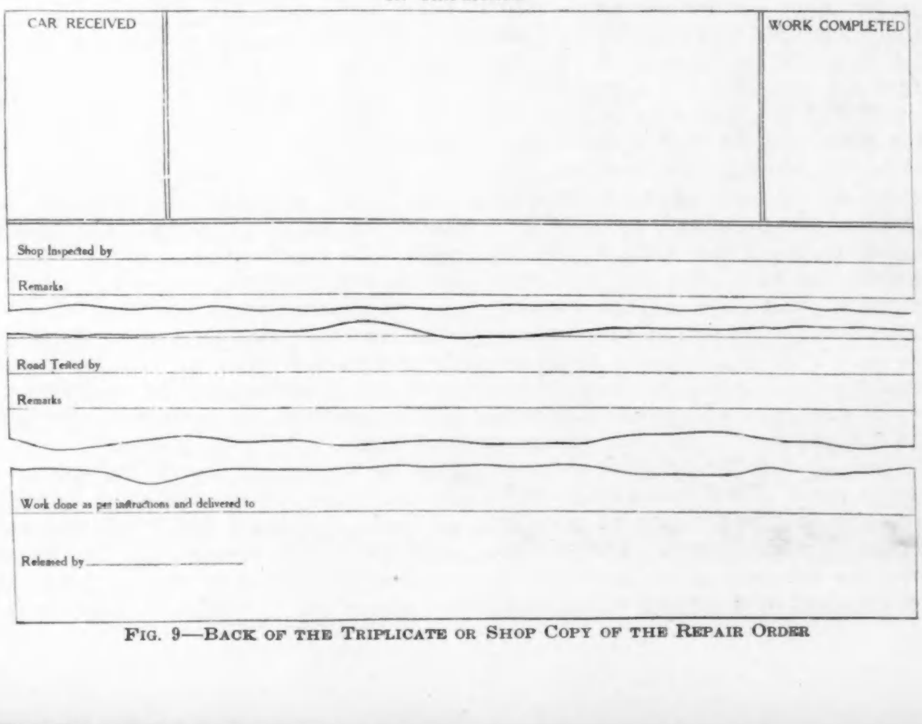
Total Charges

Promised
Date 192
Owner's Name
Address
Phone
Lic. No. | Car No. | Mileage | Deliver to

Wash and Polish
Change Oil
Alemite
Adjust Chain
Test and Adjust
Parts Supplied As Necessary
Workman

Authorized by
Received by

Fig. 8—Front of the Original Copy of the Repair Order Which Is Made Out in Triplicate



CAR RECEIVED
WORK COMPLETED

Shop Inspected by
Remarks

Road Tested by
Remarks

Work done as per instructions and delivered to
Released by

Fig. 9—Back of the Triplicate or Shop Copy of the Repair Order

The cover on the front-seat upholstery remains on the car until all testing has been accomplished. We believe that much of the success attained by many automobile service-stations can be traced directly to the fact that they are properly equipped. We find in our own particular organization that courtesy in its broadest sense has more to do with the satisfaction of customers with our service than almost any one other item. The average customer is so accustomed to short, curt replies, indifference and impoliteness that when he is faced with a courteous service-man he immediately thaws out and becomes the regular fellow that he really is underneath.

By far the greater majority of complaints regarding poor service result from misunderstandings between the customer and the service department. The logical time to prevent these misunderstandings is when the car is first brought to the service-station and the order written. One of the most responsible positions in the service department is that of the floor-man who meets the customer and attends to his wants. This man must have a pleasing personality, a neat appearance and, above all, he must know the car thoroughly. He must be a trained mechanic, electrician and tester and, if his work is properly done, misunderstandings and complaints very, very seldom arise. We aim, first, to listen attentively to the customer's story of his difficulties, either real or imaginary, and then make a careful analysis of these difficulties to the end that the repair order when written shall give the shop superintendent very definite instructions that will enable him to perform the work so that it will be exactly what the customer desires to have done, if that is possible.

Handling Work in the Shop

Our repair order, a copy of which is reproduced in Fig. 8, is in triplicate form. The original copy remains in the order office, the duplicate is given to the customer and the triplicate copy, which is of heavy cardboard, follows the car until all of the work is completed. This order contains all necessary information regarding the customer; such as his name, address and telephone number; the type of car, its mileage, factory and registration numbers and anything that may be needed for future reference. Certain printed notations call the customer's attention to work that in many cases might otherwise be forgotten. The customer, of course, is required to sign this order upon leaving the car. When the car arrives in the shop, the repair order is time-stamped on the back, Fig. 9, and turned over to the shop superintendent. Spaces are provided for signatures of inspector and road-tester and the man who delivers the car. When the work is completed the card is again time-stamped and returned to the billing office together with time-slips and stock requisitions issued against the particular order, in order that the job may be billed and ready when the customer calls. Thus, some particular man is made responsible for each step the car goes through, from the moment it arrives at the service-station until it is delivered to the owner. Under no conditions is any employe permitted to make any misrepresentations to the customer regarding the condition of his car and we take especial care, even in cases where an estimate of the cost is not requested, that the customer be given at least a general idea of the probable expense involved. We endeavor to make all estimates sufficiently high so that we shall be able to give the man as much as or more than we promise for his money. Dissatisfied customers and long overdue accounts often are directly traceable to neglect on the part of a service department to give an owner full information regarding this point.

It is very important that all work be thoroughly gone over by a well trained inspector, in addition to the supervision of the shop foreman. A great many motor cars are not performing correctly due perhaps to the need of a single adjustment that an experienced trouble-man would immediately set right. A road test is included in the work called for on every job that involves any change in the running-gear or in the engine. Our road tester is one of our very best men. To discover if a car's performance is up to average it is necessary to adopt some sort of a standard test and get comparative results. Each car that is road-tested is run over a selected road-test hill and its performance carefully checked up. The cars are started up the hill at 5 m.p.h. and at a given mark both the throttle and the spark are advanced fully. A car that is in good condition will take this load smoothly and slowly accelerate. Faulty ignition or leaky valves are indicated at this point by bucking or skipping. Too great a spark-advance or a carbon deposit is noted by clinking or knocking. Poor carburetion due to faulty setting, improper float level or a clogged line immediately becomes evident. If a car has performed well up the entire hill and passes a mark at the top at a speed of 29 m.p.h. for heavy closed cars or 33 m.p.h. for the open models it is pronounced in good adjustment so far as power is concerned. If its performance has been under the average, the tester, by the process of elimination and by repeated runs up the hill, locates the trouble and makes the adjustment on the road. If the trouble is such that it is necessary to install new parts or to do costly work not called for on the repair order, the inspector writes a full account of his recommendations on the work card. The service foreman then telephones to the owner for permission to do the work.

The upholstery in the cars is examined and cleaned just before delivery to the owner, and the steering-wheel is carefully cleaned. The necessity for this care in inspecting can readily be seen by observing the owner who drives away untroubled and the one who is bothered with petty annoyances. Imagine the feelings of the owner whose gloves are spotted with grease from the steering-wheel or whose car behaves better in some respects and worse in others. Too much attention cannot be paid to the inspection department; the cost will be easily returned in the good-will of customers who become permanent boosters.

All particular customers are not cranks. It is an admirable trait in a man to have a great pride in the ownership of a fine car and to wish to keep it in as perfect condition as possible. He is well justified in objecting to nicked rims and scratched paint on the wheels due to careless tire-changing. He is not at all unreasonable in his aversion to chewed-up screw-heads on the battery cover, or plier marks on the windshield adjusting nuts. He rightly feels that, as he is extremely careful of his own property, there is no reason why he should pay to have someone else mar it. We have one owner who comes in periodically to have his engine cleaned. After the first cleaning job, he explained rather indignantly that he wanted the engine to look as nearly like new as possible. If parts had to be removed and polished and it had to be gone over with a small brush and gasoline, he wanted it done, as cost was absolutely no object. He has since paid several fairly large bills for this kind of work, and we have never had any further trouble with him in this connection. He was simply an example of the customer who wants things done in absolutely A-1 shape and is willing to pay for it.

Flat-Rate System

The flat-rate system of service charges is becoming more and more popular with owners as well as service-stations. We believe that eventually practically all work will be reduced to this basis. Experience and careful cost systems will consequently reduce all operations to a basis that will be entirely satisfactory to the customer and provide a reasonable profit to the service-station, at the same time making business relations much more agreeable to all concerned.

Our flat rates were established only after a careful analysis of very many jobs covering a considerable period of time, and in every case our repair order shows by whom the work was performed and the exact amount of time consumed. We are thus able to determine which of our employes is most efficient in any particular line of work and compare his average time with that of the others. We base our charges, however, on the average time for a given number of similar jobs, and then if we are able by consistently using certain efficient men in any particular line to reduce this time, the shop receives the benefit. So far as possible we endeavor to keep each man in some particular line of work as he rapidly acquires a degree of efficiency that he could not otherwise attain. We allow him the greatest freedom in offering suggestions as to methods that will improve the quality of his work as well as the speed with which it is performed. We endeavor to assist him so far as possible with the best of equipment and special tools, making a study of each particular operation to eliminate all unnecessary movements.

For instance, the adjusting of connecting-rod bearings is usually a rather uncomfortable and slow operation, but by applying the above-mentioned methods we have been able to cut the time consumed approximately in half and at the same time turn out far better work. The car is first elevated in front by running it up onto a wedge-shaped incline, and the oil drained. The removal of the oil sump, which is usually a rather dirty job, is done by helpers with high-speed wrenches, and any surplus oil removed from the exposed parts. The man who actually does the adjusting is one thoroughly skilled in his work and he is supplied with special racks and a crate in which he has every tool required for the operation and a place to lay all the parts that it will be necessary to remove while the operation is being performed. Thus, when he once takes his position under the car, it is never necessary for him to come out until the work is completed. We find that with this comparatively simple equipment the men rapidly take a greater interest in their work and in the speed with which it can be performed. But in no case do we ever risk quality for speed. This same procedure has been carried out in connection with every other operation on which we could possibly establish a flat rate and has proved very satisfactory and profitable.

Securing Cost Data

In addition to the customary time-clock record, our workmen are all required to keep a day card, a portion of which is reproduced in Fig. 10, on which they record the various jobs on which they work during the day, accounting for every minute of their time. These cards are tabulated each day by one man whose duty it is to segregate each man's time into the proper divisions, recording it under the following 17 headings used in the distribution of all labor:

No. Date	MORN	IN		
	NOON	OUT		
NAME	NOON	IN		
Hours Rate	NIGHT	OUT		
Amount	Overtime	IN		
Form K 14952	Overtime	OUT		

ORDER No.	WHAT ARE YOU DOING?	CLOCK RECORD		
		Stop		
		Start		
		Stop		
		Start		
		Stop		
		Start		
		Stop		
		Start		
		Stop		

Fig. 10—The Workman's Day Card on Which He Keeps a Record of the Various Jobs Worked on during the Day

(1) Productive Labor
(2) New Car
(3) New-Car Service
(4) Used Car
(5) Used-Car Service
(6) Shop Labor
(7) Stock Room
(8) Garage Labor
(9) Lost Time
(10) Guaranteed Work
(11) Company Business
(12) Chauffeur
(13) Maintenance of Building
(14) Maintenance of Demonstrating Car
(15) Maintenance of Company Car
(16) Maintenance of Official Car
(17) Tractor Department

At the end of the week this time is reduced to cost and the cost classified on a large sheet that permits us to determine at a glance the exact cost to us for the labor consumed during the week in each of these 17 departments. We are thus in a position to check up very closely on what is going on in our service department, to reduce as far as possible our non-productive labor and to increase the efficiency of the men. By the use of these sheets we were enabled during the first three weeks to increase our productive labor 5⅓ per cent and, at the same time, decrease our percentage of non-productive labor 5⅔ per cent. We are hopeful of some very fine results from this system after it shall have been in operation a greater period of time. This system is kept so accurately that the accounting department can use it for making all charges to the new-car department, used-car department, officials and other accounts, and from it we obtain an absolute record of each man's time during the week and get very valuable information regarding the efficiency of the individual.

The time is coming when there must be a complete understanding in every automobile organization between the sales and the service departments. The salesman will have to learn some of the elements of service; what it is, what the service department is capable of doing and what its limitations are. The salesman will not be allowed to hide behind false excuses when a customer demands that a verbal contract made when he bought the car be lived up to.

There shall be coordination all along the line from the

maker to the helper in the service-station. We have striking examples of how service may be impaired through lack of this element in the way railroads are operating today as a result of shopmen leaving their work, or not doing it properly when the men are disgruntled. Transportation broke down.

The motor-car industry is furnishing a means of transportation that in many ways is supplanting the railroads. This is increasingly evident year by year. The industry has grown to tremendous proportions because of this fact. It must continue to grow. But it cannot grow adequately if there is any impediment in its path, and the one big impediment that could stop its progress is lack of service. We have been growing too fast to realize this until now. It is time we faced the proposition squarely. Let us build our industry upon satisfactory service. It will prove a foundation that will enable us to reap the rewards to which we are entitled for furnishing mankind a means of bridging distance and multiplying the value of his waking hours, a thing whose worth it is impossible to measure in dollars and cents.

Standardized Mental Test in Personnel Selection[1]

By Dr. W. V. Bingham[2]

A ROUGH measure of the brightness, or mental alertness, of an applicant, by a standardized mental test, has long been recognized as one of many possible sources of information for use in personnel selection. Early tentative attempts to use this test technique in employment procedure sometimes met with anomalous results because it was not recognized that, for some types of employment at least, an applicant may be too intelligent.

In affiliation with the Carnegie Institute of Technology, Pittsburgh, a group of 27 companies of national scope established, in June, 1916, the Bureau of Salesmanship Research, now the Bureau of Personnel Research. This Bureau was to pool the experience of the cooperators to evaluate their current procedures and to devise and try-out new ways of selecting and developing salesmen. The first year's work, under Walter Dill Scott, was issued in a volume of Aids in Selecting Salesmen that included an improved personal-history record, or application form, a model letter of reference to former employers, a guide to interviewing that helped the interviewer to focus his attention on essential traits and to record his judgments quantitatively,[3] and a set of five psychological tests with full directions for giving and scoring.

Among these tests was a group intelligence examination, a forerunner of Army Alpha. It was given to various groups of salesmen and sales applicants, and their scores were checked against actual success as measured by amount of sales. Among the men so examined was a group of 40 salesmen for a food products company. To the dismay of the research workers, when the intelligence-test scores were compared with the men's sales-production records, the correlation was almost zero. This appeared to be a severe indictment of the test as a measure of intelligence.

Then came the war, and with it a vast experience in personnel classification and intelligence examining. The psychological tests proved their worth in the Army as indicators of mental alertness. So when C. S. Yoakum, with this background of Army experience, in 1919, assumed direction of the Bureau of Personnel Research, he knew that the intelligence-test methods were valid, and he sought another explanation of the riddle in the findings of 1916. Taking the same data, he computed the correlation between test scores and length of experience with the company. The correlation was not zero. It was negative, —40. The brighter the salesman, the quicker, as a general rule, he left the employ of that firm.

Mr. Yoakum repeated the experiment with 76 salesmen of this same company, using the best available adult intelligence examination. The correlation of test scores and length of experience was 46. A job analysis revealed that the work was largely of the routine, order-taking sort. The pay was not large. Chances of promotion were slight. Only the more stolid men were content to remain long enough to get valuable experience and build up a creditable sales record.

Examining the intelligence scores again, it was apparent that there is an upper limit as well as an anticipated lower limit. Within this range, the chances are large that an applicant for a position with this company will make good. Below this zone he will probably fail for lack of ability. Above it, the probabilities are that he will not remain long enough to learn his work thoroughly and make a good showing. The psychological test had, after all, been a valid measure of mental alertness. The need had been for a determination of its range of utility.

This range varies for different kinds of salesmen, as well as for different occupations. In many jobs it has been shown that there is no upper limit to the optimum intelligence score; but studies of policemen, salesmen and many types of operatives and clerical workers, where the task is essentially routine, have shown how necessary it is to keep an eye on the upper as well as the lower critical score. Research on the utility of psychological methods in employment and placement is but one of many scientific approaches to problems of industrial personnel. Taken as a whole, the scientific study of the human factor may prove as important to the next era of industrial progress as research in the physical sciences has proved hitherto.

[1] Issued by the Engineering Foundation.

[2] Director of cooperative research, Carnegie Institute of Technology, Pittsburgh.

[3] This form later became the Scott Rating Scale of the Army.

TRAFFIC

A SAVAGE can travel after a fashion in a jungle. Civilized activity is too complex to be carried on without smooth roads. It requires signals and junction points; traffic authorities and means of easy and rapid transportation. The eternal dignity of labor and art lies in their effecting that permanent reshaping of environment which is the substantial foundation of future security and progress.—John Dewey.

Proper Utilization of Natural Gasoline

By LLOYD F. BAYER[1]

ANNUAL MEETING PAPER

THE term "natural gasoline" has been accepted generally by the petroleum industry as applying to the gasoline product extracted by any process from natural gas. Two processes are in use. The older one is the compression process applied to casinghead gas, which is produced from the oil-bearing sands of oil wells and carries vapors from the oil with which it has been in contact. This process of subjecting the relatively rich gas to a high pressure and then cooling it to or below atmospheric pressure, results in the direct condensation of gasoline which is weathered later to remove the "wild" unusable vapors.

The later method is the absorption process in which the gas is brought into contact with a heavy oil, originally of no gasoline-content, which absorbs the gasoline. The enriched oil is then heated to distill-off the gasoline, and these two operations of absorption and distillation are repeated continuously within a closed system.

The author discusses the proper usage of natural gasoline in blended fuels as determined by a lengthy series of tests.

THE problem of securing the largest possible supply of the best possible motor-fuel is before the petroleum industry. It is a problem so intimately connected with the problems of automotive power and engine design that it can be said to be a joint problem with the automotive industry. Certainly the petroleum industry cannot expect to supply motor-fuel, in the quantity production that it is being called upon for, without due regard for the problems of fuel economy and life of the engine. On the other hand, the automotive industry cannot say, without regard for the element of quantity production, that it must be supplied with a fuel uniform in quality and having none of the, from its standpoint, objectionable properties that have characterized some of the motor-fuel of the past few years. This fuel has been put out by the petroleum industry in its effort to meet the constantly increasing quantity demand. A medium quality will prevail between the present so-called superior and inferior grades now being manufactured, with the ever-increasing necessity of decreasing the quality to increase the quantity. With both industries coordinating their efforts, that is, by each working with a knowledge of the other's problems, a happy medium can be reached; otherwise, at least, it will be an unhappy medium for one of the industries, and surely for the consumer.

Natural gasoline is destined to play an important part in the solution of this problem. As to a definition of this product, following the organization of the Association of Natural Gasoline Manufacturers, in the Middle West, the term "natural gasoline" was adopted by it and has since been accepted generally by the petroleum industry to apply to the gasoline product, extracted by any process, from natural gas.

"NATURAL GASOLINE" PROCESSES

In general, without taking account of the myriad of varying details, two processes are in use. The older one is the compression process applied to casinghead gas, that is produced from the oil-bearing sands of oil wells and that carries gasoline vapors from the oil with which it has been in contact, thus giving rise to the term "casinghead gasoline." This process of subjecting the relatively rich gas to a high pressure and subsequently cooling it to or below atmospheric temperature, results in the direct condensation of gasoline that is weathered later to remove the "wild" unusual vapors. The later method is the absorption process in which the gas is brought into contact with a heavy oil, originally of no gasoline-content, that absorbs the gasoline. The enriched oil is then heated to distill off the gasoline. These two operations of absorption and distillation are repeated continuously within a closed system. This process was first applied to the natural gas transported through pipe-lines for commercial and domestic use. This gas was very lean in gasoline content. The process has since been developed to the point where it is now rapidly displacing the compression method for all kinds of both lean and rich gas.

With the production of automobiles and the consumption of gasoline mounting at a rapid rate, and our domestice sources of crude oil being increasingly drawn upon, the necessity is apparent for obtaining more gallons of gasoline from each barrel of crude oil produced. The refiner and his staff of experts are constantly devising and perfecting means of making more gasoline from the crude oil. They are accomplishing this, first, by a sharper separation of the fractions cut from the crude; second, by the installation and operation of cracking processes designed to convert substantial proportions of gas oil, fuel oil, or heavy distillate, to gasoline similar in general characteristics to that produced directly by distillation; and, third, by the use of natural gasoline, to render sufficiently volatile for satisfactory gasoline certain fractions of the crude that, of themselves, would not meet the requirements of an acceptable grade of motor-fuel.

It is to this third phase that I direct attention, developing the subject less from the refiners' and natural gasoline manufacturers' point of view than from that of the automotive engineer and the automobile user. The interests of the consuming public in utilizing natural gasoline can be served best by using a relatively uniform percentage of this product in all the motor-fuel consumed during a given season of the year, and varying this percentage to meet the varying demands of the different seasons. This is, of course, a general statement. The required percentage is subject to variation due to the inherent characteristics of the gasoline cut from the crude oils and to varying climatic requirements of different sections of the country.

USAGE OF NATURAL GASOLINE

With all motor-fuels, particularly those of higher end-points, it is desirable to increase the percentage of natural gasoline used in the winter over that used in the summer to assure the greater volatility necessary. Although the consumption of gasoline is considerably less in the winter than in the summer, and the production of natural gasoline slightly greater in the winter, it is both practicable and desirable from the point of view of the gasoline manufacturer, the refiner and the consumer, that the percentage of natural gasoline in motor-

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fuel be increased sufficiently during cold weather to utilize currently the production of natural gasoline.

It is peculiarly fortunate that approximately the same ratio exists between the available amount of natural gasoline and the total production of motor-fuel, as exists between the proportion of natural gasoline that should be used in this motor-fuel if the most satisfactory quality is to be obtained. In other words, the production of natural gasoline is close to 10 per cent of the total gasoline production, while 10 per cent is a very satisfactory proportion in which to use natural gasoline with the average motor-fuel to give that motor-fuel the desired quality characteristics. When accurate figures are available, the percentage of production for 1922 undoubtedly will be found to exceed this, due, largely, to a great increase in its production in Texas. As the natural-gasoline possibilities of the existing oil-fields are now very largely developed, increased production will come almost entirely with an increased crude-oil production. A great increase in the percentage of natural gasoline available, compared to the total gasoline production, is therefore not to be expected.

The figure of 10 per cent given as the proper proportion in which to mix natural gasoline with motor-fuel is indicated by a large number of tests that have been made, but this percentage should be taken as a minimum rather than a maximum. As high as 20 per cent frequently is desirable. Thus it is seen that the problem becomes one of uniform distribution of the natural gasoline available, to the end that all motor-fuel consumed shall carry its most desirable proportion, and no motor-fuel be produced with an excessive proportion of it.

The use of natural gasoline in the past has been attended with varying success, depending altogether upon the experience and intelligence, or the lack of it, that has been displayed in combining it with other products to form the finished motor-fuel. Many arduous and expensive investigations have been conducted, in both the laboratory and the practical operation of engines, to determine the best possible proportions and combinations to secure an altogether desirable product. It is to the facts thus obtained that I wish to direct attention.

Blended Fuels

Prior to the acquisition of the present knowledge of this subject, natural gasoline was so commonly on the market in the form of blends improperly made as to place all natural gasoline in disrepute and to foster strong prejudices, the overcoming of which has required considerable time and a practical demonstration of the good results to be obtained by proper methods. The unsatisfactory types of blend referred to were unfitted for use as motor-fuel for one or more of the following reasons: first, some of them used kerosene as a blending base; second, too great a percentage of natural gasoline was blended with a heavy naphtha; third, natural gasoline of too high volatility was used.

In the first case, it was attempted to blend two entirely dissimilar products, the boiling-point range of one of which was entirely beyond that of the other. It also utilized kerosene, which the carbureter was not designed to vaporize and which, when finally introduced into the cylinder in a partially vaporized state, caused crankcase dilution and excessive knocking. The second and third practices resulted in the same trouble due to too great volatility; they caused an excessive evaporation-loss, gas binding in the gasoline feed-system, and an uneven operation and a loss of power when the engine was thoroughly heated-up.

The Association of Natural Gasoline Manufacturers is bending every effort to eliminate the types of blend that are objectionable, and to produce only blends that are satisfactory. It has issued and lately has revised standard specifications for blends of the several commercial grades. It has also formulated standard specifications for natural gasoline in its unblended state, so that the refiner can demand and receive the product suited to his needs.

Results of Tests

Evaporation tests conducted through every month of the year by a large refinery indicated that the evaporation loss on a blended gasoline containing 10 per cent of natural gasoline combined with 90 per cent of refinery gasoline slightly deficient in volatility, was no greater than the loss on a refinery gasoline of the same characteristics as the blended gasoline. With an increase in the natural-gasoline content to 15 per cent, the evaporation loss was very slightly greater than in the case of the refinery gasoline; but there was a compensating advantage in the volatility characteristics of the gasoline.

A long series of dynamometer tests conducted at full and one-half throttle over the entire speed-range from 400 to 1600 r.p.m. proved that the addition of 15 per cent of natural gasoline to a good commercial gasoline increased the brake horsepower developed and decreased the pounds of fuel consumed per horsepower-hour. The basic gasoline used was equal or better than the average gasoline sold along the Atlantic seaboard, having an end-point of 405 deg. fahr. The starting and accelerating characteristics were improved with each additional per cent of natural gasoline used and, although the improvements were very marked at 10 per cent, they did not reach the maximum increase in brake horsepower and fuel economy until there was a mixture with 15 per cent of natural gasoline. This means that the motorist who uses the fuel containing from 10 to 15 per cent of natural gasoline obtains more power at the same carbureter-setting or, by adjusting his carbureter, he can decrease the fuel-consumption. With either result he also enjoys much improved starting and accelerating effects.

A number of well known investigators have come to the conclusion that the temperature at which 85 per cent of the gasoline distills off in a standard distillation-test is of more importance than the end-point, and measures more nearly whether the gasoline will be vaporized completely in the engine after it is warmed-up. This point is fixed by the percentage of heavier constituents in the product and is controlled by the process used in the original separation from the crude, by either low or high-pressure distillation. In many instances the fractions cut that would be satisfactory, so far as either the 85 per cent point or the final end-point is concerned, do not make good motor-fuels, due to a deficiency in the light ends that are necessary for quick starting and snappy acceleration when more power is called for. Therefore, to obtain a good fuel, it is necessary either to sacrifice the yield materially or to add the proper volatile constituents.

Proper Blends of Fuel

The sacrifice of yield is no more desirable to the consumer than to the refiner, for such a policy generally carried out cannot but result in higher prices due to the natural law of supply and demand. However, by adding 10 per cent of natural gasoline, the initial boiling-point can be lowered from say 15 to 25 deg. fahr., and the percentage distilled at 212 deg. fahr. can be increased

by from 6 to 9 per cent. Thus, a gasoline that, unblended, would have an initial distillation temperature of 130 deg. fahr. and 18 per cent distilled off at 212 deg. fahr., would be improved with 10 per cent of natural gasoline to have an initial distillation-temperature of approximately 110 to 115 deg. fahr. and the percentage distilled at 212 deg. fahr. increased to 25 or 26 per cent. From all points of view, this would be a very much more desirable gasoline. If 15 per cent of natural gasoline is used, the initial boiling-point can be lowered 20 to 30 deg. fahr., and the percentage at 212 deg. fahr. can be increased by from 10 to 12 per cent. Thus, the same unblended gasoline mentioned just previously, combined with 15 per cent of raw, would produce a finished motor-fuel having approximately an initial boiling-point of 105 to 110 deg. fahr., and from 28 to 30 per cent distilled at 212 deg. fahr. Thus, the refiner can make his cuts to produce a product with the 85 per cent and the final points desired, and then increase the volatility of this product with the proper proportion of natural gasoline, thereby increasing his total yield of motor-fuel from the crude.

This improvement in quality by the addition of natural gasoline in high-grade motor-fuels is even more noticeable in the case of fuels of high end-point but still well within the range of commercial utilization. The results so far obtained by the joint tests being conducted at the City of Washington by the Bureau of Standards and the Society of Automotive Engineers indicate that a motor-fuel with an end-point of 465 deg. fahr. is as satisfactory, so far as mileage is concerned, as fuel with approximately a 405-deg. fahr. end-point. These are the results only of the summer series of tests, and the only appreciable disadvantage noted is the increase in the crankcase dilution. So far as we know, it has not been determined whether the dilution noted was sufficient to be detrimental. The fuel so used did not contain natural gasoline, at least not in a known or an appreciable percentage, and it has been requested that similar tests be conducted using fuel blended with a suitable proportion of natural gasoline.

Advantages of Natural-Gasoline Blends.

It undoubtedly is true that the principal cause of crankcase dilution is the excessive use of the choke required in starting on fuels not sufficiently volatile. In such cases a large quantity of gasoline, almost wholly in liquid form, must be drawn into the cold engine to obtain sufficient easily vaporizable gasoline to produce an explosive mixture. The large portion of the gasoline that is not vaporized drains past the piston-rings, destroying the piston seal, and enters the lubricating oil in the crankcase, greatly diminishing its viscosity and reducing its lubricating value. With the proper proportion of natural gasoline, sufficient volatile fractions are present to form an explosive mixture without drawing these large volumes of fuel through the engine. After the engine is warmed-up and under way, the additional volatility assists in more complete vaporization, and the complete combustion of the gasoline greatly reduces the possibility of dilution.

The action of an engine using a fuel of 437 or 450-deg. fahr. end-point is improved greatly when that fuel is blended with natural gasoline. The acceleration from low to high speed is rapid instead of sluggish. The fuel-consumption with the blended gasoline is lower in such accelerations tests, because it takes so much less time under open throttle to reach the desired speed.

Because of the economic factors involved, the trend seems to be toward fuels containing a greater percentage of the heavier ends and therefore of higher end-point. By combining with this fuel a proper percentage of natural gasoline to introduce the necessary readily volatile constituents, a motor-fuel of relatively higher end-point can be utilized with the same satisfaction as that secured from gasolines of much lower end-points. This will increase the available supply of gasoline from a given production of crude oil, and will benefit the consumer directly. When this stage is reached, generally, it is very doubtful whether the development of a kerosene carbureter will be required, as, by that time, the increased yield of gasoline will have reduced the kerosene yield to a point where it probably will meet only the regular demands for heat and illumination.

The conclusion that I wish to emphasize is that, through the uniform distribution of the available supplies of natural gasoline, so that substantially all motor-fuels will carry their due proportion of it, an increased quantity of motor-fuel of increased quality will result. This is a result devoutly to be sought by the petroleum industry, the automotive industry and the consuming public.

TERRAIN FOR GLIDER CONTESTS

A LONG ridge is preferred rather than a detached shaped hill. The slope must face the direction of the prevailing wind and should be reasonably uniform and of proper magnitude. The slope should be approximately 1 in 4 near the top of the hill, decreasing to 1 in 6 or 8 a short distance below the top. A constant degree of slope, however, would be satisfactory, even if it be nowhere in excess of 1 in 6. The hill should not be conical, but have a side broad and flat or somewhat concave in form as viewed from above. An ideal condition is a sloping valley facing the prevailing wind, wide and open at one end and contracting gradually between two ranges of hills until finally completely closed-off at the other end by the hill from which the flights would be started. Such a valley would, however, not only have to face the prevailing wind but no gliding could be done with any wind from any other direction. An open range of hills would have the very marked advantage of allowing a certain amount of deviation in the direction from which the wind blows.

A total drop of 1000 ft. from the hill to the plain below is highly desirable. A height of 100 ft. is the least that could be considered. The nearer the base of the hill approaches absolute sea-level height, the better. The surface must be smooth and as free as possible from trees, shrubbery, telephone wires or other obstructions.

Preferred locations are in parts of the country where the required velocity of wind during the hours that the contest is to take place occurs at not infrequent intervals; a mere daily average is not sufficient. The wind should be of more than 15-m.p.h. velocity, and preferably 20 or 25 m.p.h. continuously for hours at a time. The hill should be accessible by good roads and car-lines for the benefit of spectators and contestants.—Communicated by National Aeronautic Association.

Testing Leather Substitutes and Top Materials

By J. B. Davis[1]

Annual Meeting Paper *Illustrated with* Photographs and Charts

ALTHOUGH waterproof protective material has been in use for many centuries, particularly in the Far East, its manufacture in this Country was not begun until about 1850, and not until the arrival of the motor car did the demand for so-called leather-cloth cause its production to take a jump. This demand has increased until in 1922 the record-breaking quantity of 50,000,000 sq. yd. was consumed. The growing popularity of closed bodies has produced a corresponding call for leather-cloth and the importance of classifying and of embodying standard tests in the specifications for it is receiving close attention.

With the view to assisting in the establishment of uniform tests for the various qualities that are desirable in high-grade leather-cloth, the tests in use by one of the largest manufacturers are described, and suggested specifications for top material, upholstery and special body leather are given. Particular requirements will determine the desirability of muslin, drill, twill, sateen, moleskin or duck, and the suitability of each is judged by the weave, construction, thread-count, weight and the like. Among the qualities that can be determined by tests, directions for which are given, are resistance to wear; tensile strength; bonding-strength; resistance to stretch and puncture; thickness; toughness and adhesion of coating; resistance to water, shrinkage, fire and heat; cleansability and resistance to gasoline and the effect of aging.

FOR many thousands of years man has found various means for protecting himself against the elements. From the time of the earliest Egyptian and East Indian potentates with their gorgeous silk canopies to that of the present-day man who rides in his own motor-car, weather protective mediums have been in use. In the Orient the Chinese and the Japanese in particular provided themselves with waterproof cloths, silks and papers, which for many centuries have been manufactured largely by hand. They are now calling on the United States to supply them with a black leather-cloth for the collapsible tops used on the man-drawn two-wheel rickshaw, as well as for a small output of automobile bodies.

The first leather-cloth of any value was manufactured in England early in 1800 and was used principally for the hoods of perambulators, as it is used today. Leather-cloth was first manufactured in this Country about 1850. In the early stages of its development a few hundred yards a day was considered a big production, while today it is made at the rate of millions of yards a year for the automobile industry alone.

Several well-known automobile companies 20 years ago were building fine carriages, coaches and buggies, on which leather-cloth was used for tops, curtains, upholstery, storm-aprons and dashboards. The material was designed and constructed for special purposes at that time as it is today. With the first commercial production of motor cars early in 1900, the problem of weather protection came up for consideration and, naturally, the leather-cloth products that had proved so satisfactory for carriages were adapted to the early automobile; grandfather's buggy-top was becoming the one-man collapsible top. Some of you remember the carriages made with a dashboard and whip-socket of leather-cloth with patent-leather finish. As the automotive industry through the various stages of its development grew in both volume of production and quality refinements, so with it grew the volume of production and quality refinements of leather-cloth.

Present State of Development

The automobile industry in 1922 produced over 2,500,000 passenger and commercial cars including motor trucks and consumed approximately 50,000,000 yd. of leather-cloth of various qualities for approximately 20 separate and distinct uses in constructing and equipping motor-car bodies. A few of these uses are one-man collapsible tops, curtains, upholstery, linings, gimps, welting, trunk-covers and lining, mud-flaps, spring-covers, covers and curtains of truck cabs and the like.

In the last few years the patent-leather finish has been used largely in the construction of closed-car bodies. This retains all the good features of a metal-covered body with its full curved contour, and overcomes many of its disadvantages, not the least of which is the initial cost of working and finishing. You probably all have had patent-leather shoes forced upon you on some occasion and have noted their remarkable resistance to scratching. The non-scratchable quality of patent-leather finishes has many advantages over painted and varnished steel surfaces in body-construction.

Let us leave for a moment the possibilities of these new applications of leather-cloth to closed-car construction and consider its relative importance in the construction of bodies and tops for open models. Nothing can detract from the beautiful lustrous finish of car bodies more than a shabby, baggy, faded and dead-dull collapsible top. The top may have looked well when it was shipped; possibly it had a short life under weather conditions. Many of you probably have scratched your heads after a final look at your new model just out of the finishing department and wondered, "How will it look 6 months from now?" We all like to impress our friends and neighbors with our good judgment in buying a car. Our reputation as good purchasers depends, however, not only on the original lustrous appearance of our cars as we drive up in front of our homes on a fine April morning, but rather more on their ability to retain apparent newness through the biting sun and dust of July and August, the snow, sleet and cold of the winter months, the high winds and driving rains of March, and in certain localities, the effects of alkali sand and mud.

[1] Production manager, Standard Textile Products Co., New York City.

Many no doubt have watched a string of cars being driven up the main thoroughfare of a large city and noted the dead-dull appearance of many of the tops of the cars, obviously only a few months old. You may be assured by this sign that a disintegrating process has set in and that the material has begun to fail. When this condition is noticed by the owner and his friends, it is a subject for unfriendly comment that in no way satisfies his pride in his choice.

Standardization of Leather-Cloth

The enormous growth of the application of leather-cloth to motor-car bodies makes it prominent among materials, the requirements for which are being daily studied, specified and tested. The Society has made remarkable strides in standardizing automotive parts and material, having covered some 250 items since the inception of its Standards Committee in 1910. In carrying out this commendable program of standardizing, specifying and testing material you have established within your plants well-equipped chemical and physical laboratories for scientifically testing the materials that enter into motor-car construction. Would it not be logical to adopt uniform, scientific tests and to specify them for the leather-substitute products that add so much to the original appearance of the car and the continued satisfaction of the owner? There are very many makes of leather substitute on the market to choose from, none of which may be perfect. You can figure their comparative prices but not always their original qualities or their life, durability and service, nor can you match all the various quality characteristics one against the other, judging which products possess that proper balance of qualities that will best meet your requirements. A properly standardized test would place you in a position to distinguish the advantages and measure numerically the more important quality characteristics of any leather substitute.

Leather-cloths, of single or double texture, can be segregated, clearly defined and recognized under certain general classes, that depend upon the purposes for which each is to be used. The construction of the cloth used as a foundation, the dyeing and the coatings applied, all have a bearing on successful utilization. Selecting a suitable leather-cloth is almost as difficult as making it. As users you are interested first in the quality and secondly in the price; on account of the small yardage used on each car the price is of less importance. The two leading attributes are likely to be durability and appearance. In attaining these the responsibility of the maker is as great as that of the user. Each should have a scientific method of testing the products, for many instances have occurred in which on account of the lack of a proper test good products have failed of acceptance; and by the same token a few poor products have been adopted temporarily, usually to the ultimate loss of the user.

I shall show, with the aid of a few views and charts, how testing equipment can be utilized for measuring numerically the many qualities of leather-cloth and shall try to interpret the readings in terms of durability and permanence of appearance. The general appearance, with regard to luster, smoothness, softness, finish and color, can be judged and interpreted by comparing standard samples.

Method of Testing Quality

Many years ago it was the practice to set up in a field a group of discarded top-frames on which were stretched

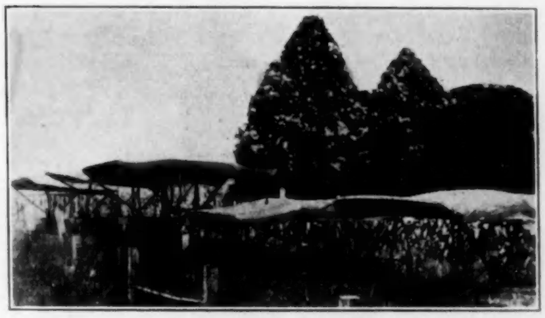

Fig. 1—Former Method of Testing Life of Materials by Exposure to the Weather

the various materials for comparative test under actual weather conditions, as shown in Fig. 1. The tops were opened and closed from time to time. This necessitated a loss of time of 6 months to a year. This method does not serve in these days when decisions must be made and volume production had with the shortest possible delay to meet the rapidly changing condition of the market.

I shall present for your consideration the quality-test method for leather-cloth products that has been developed by our staff in cooperation with the United States Bureau of Standards. The serviceability of automotive leather-cloths depends not only on the raw material but on the process by which the goods are made. A chemical analysis will, as a rule, not be as indicative of quality as the physical tests that represent the stresses to which the goods are to be subjected in actual use. The nature and construction of the fabric, however, are of some importance. For example, a very heavy fabric would not be suitable for use in side-curtains that generally are folded or rolled up and tucked away under the seat of the automobile. On the other hand, upholstering material that is stretched and nailed and later subjected to severe usage must be made from a rigid fabric that cannot easily be pulled out of shape or torn. The particular requirements will determine the desirability of muslin, drill, twill, sateen, moleskin or duck, and the suitability of each is judged by the weave, construction, thread-count, weight and the like. These points may readily be ascertained by the ordinary methods of fabric analysis.

Weight is one of the most important physical characteristics and is easily determined by placing a definite length, as 12 yd., on a scale. The procedure may be carried out in the laboratory illustrated in Fig. 2. Samples are carefully chopped out with a 3 x 3-in. die. These are weighed in centigrams on a torsion-balance and the weight of the units of the desired area is established. For example, the weight in grams multiplied by the factor 5.08 will give the weight in ounces per square

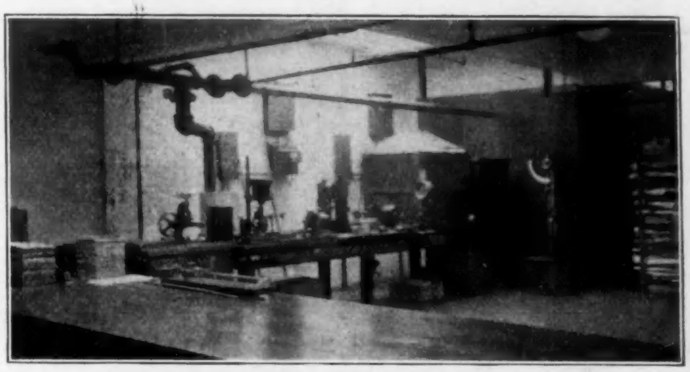

Fig. 2—View of a Modern Laboratory Equipped To Test the Various Qualities of Automotive Material

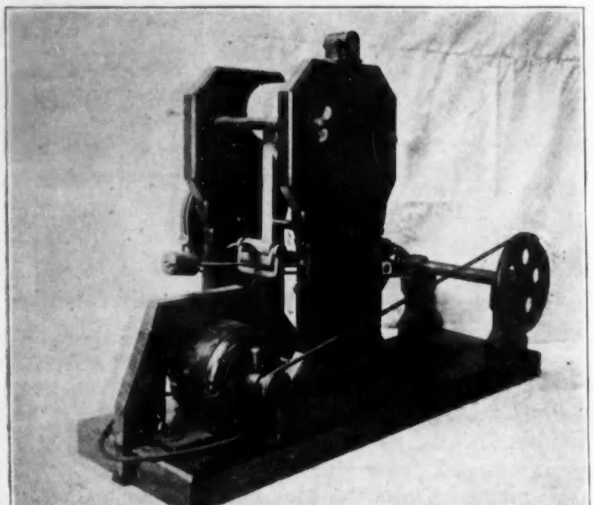

FIG. 3—ABRASION MACHINE DESIGNED TO REPRODUCE IN THE LABORATORY THE USAGE THAT AN UPHOLSTERING MATERIAL WILL RECEIVE IN SERVICE

yard. Ounces per square yard times the factor 1.04 will give the weight in pounds per piece 50 in. wide. The test is made under standard conditions of 65-per cent relative humidity and a temperature of 70 deg. fahr.

The uniformity of quality depends largely on the uniformity of weight. This does not necessarily mean that greater durability may be expected from very heavy materials. There appears to be a limit each way; extreme "body" is almost as bad as extreme "flimsiness." To secure a uniform product, it is desirable to establish a standard weight and provide for a reasonable degree of tolerance for each class of material. Conformity to the standard weight will result in a greater uniformity of strength and of wearing quality.

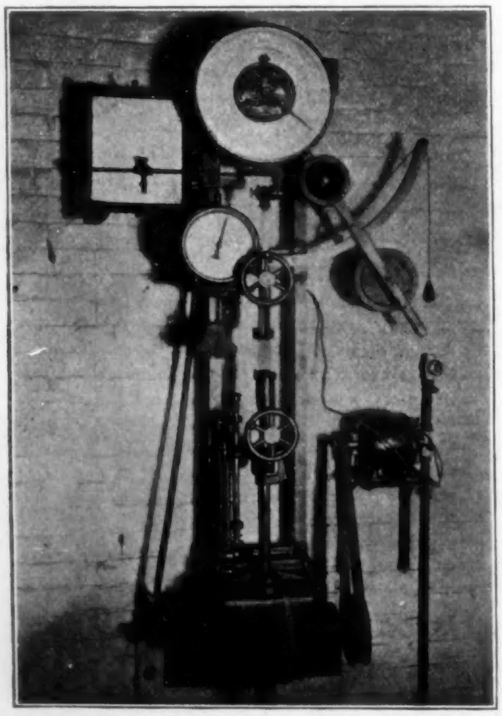

FIG. 4—THE SCOTT DYNAMOMETER EQUIPPED WITH AN ATTACHMENT FOR TESTING THE DEGREE OF ADHESION BETWEEN THE BASE AND THE COVERING

The severe usage that upholstering material must withstand in constantly rubbing against clothing very soon tells on cheap material. The coating wears away, peels off and shows the bare fabric, which has very little resistance to wear. In view of the fact that the material is placed under some degree of tension before it is nailed to the seat frame, the wearing qualities will be greatly reduced unless the coating is made of a very durable fabric. The abrasion machine shown in Fig. 3 was designed to reproduce as nearly as possible in the laboratory the exact type of punishment that the goods receive on a car. The method recommended is to fasten strips 30 in. long and 1 in. wide between the jaws of the abrasion machine at such a tension as to raise the weights just off the supports while the machine is operating. The most suitable wearing surface is a fresh piece of muslin that has a thread-count of about 60 x 60. The tension is adjusted during the operation to take up the stretch. The number of rubs is recorded upon a small counter that is attached to the machine. After 1000 rubs, and again after 2000 rubs, have been recorded by the counting attachment, the goods are examined, and at between 2500 and 3000 rubs the sample is removed. The test may be prolonged for special purposes. We have examined some samples on which the coating was very badly worn at 500 rubs and was so far removed that the fabric showed through at 1000 rubs. On the other hand, some materials are so durable that from 3000 to 4000 rubs are required to produce any noticeable effect. This test also indicates the resistance of top material to abrasive action. We consider this a very important test of leather-cloth on account of its direct indication of the hardness of the coating, which foretells the wearing quality.

It is important that the goods possess sufficient strength and rigidity to withstand the normal wear-and-tear of service. Limiting requirements should be adopted for each class of material. High tensile-strength is necessary for leather-cloth that requires great resistance to tearing or breaking under service strain. Good grades of properly constructed leather-cloth generally run higher than the corresponding grades of leather.

The "grab" method should be used to determine the tensile-strength. Strips are cut parallel to the warp and the filling threads should be 4 in. long and 1¼ in. wide. The jaws of the machine are set 1 in. apart with a 1-in. clamp. The speed of the lower jaw is regulated to 12 in. per min. and an average of at least three breaks is obtained. Table 1 shows the high and low points of a large number of samples examined in our laboratory, and indicates the variation that may be expected in the different commercial brands. If you desire a very strong material that cannot easily be ripped from the bows, you must subject it to a scientific test to determine its suitability.

TABLE 1—VARIATIONS IN THE TENSILE-STRENGTH OF AUTOMOTIVE MATERIAL

Kind of Material	Warp		Filling	
	Maximum	Minimum	Maximum	Minimum
Upholstery...	215	100	160	90
Top.........	180	120	120	75
Curtain.....	145	70	95	50

To produce a piece of goods with a very even coating that will not appear thready when stretched, and at the same time to increase the strength and water-resistance

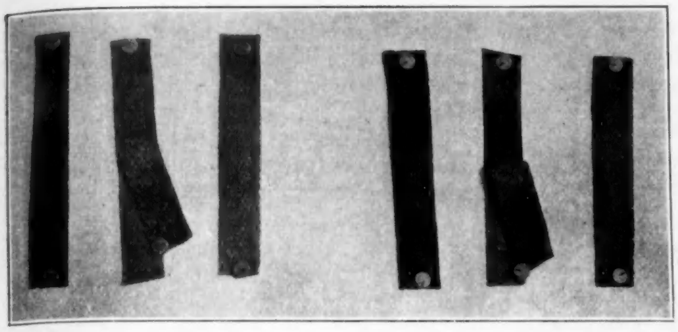

FIG. 5—TYPICAL STRIPS THAT HAVE BEEN TESTED FOR ADHESION

and overcome the diagonal stretch due to the method of constructing sateen and twill-base fabrics, some manufacturers cement two fabrics together before laying on the coating. In such cases it is very important that the cement be very strong so that the plies will not separate when they are stretched over the bows of the automobile top. The separation of the plies results in general weakness and greatly reduces the resistance to water. The degree of adhesion between the two fabrics may be conveniently determined by an attachment to the Scott dynamometer illustrated in Fig. 4.

In testing the bonding-strength, strips 8 in. long and 1 in. wide are taken out parallel to the threads, in either the warp or the filling direction. The separation of the plies is started with a knife and they are stripped back about 2 in. One end is fixed in the upper jaw and the other in the lower jaw of the dynamometer. The motion of the lower jaw continues the separation at a uniform speed of 12 in. per min. The tension required is shown on the balance dial. This must be watched during the separation. The pointer will be approximately steady about an average point. Tearing the threads must be avoided by cutting the sample properly. For example, the pointer might vary from 2 lb. 6 oz. to 2 lb. 10 oz., in which case we should call the bonding-strength $2\frac{1}{2}$ lb. per in. Fig. 5 indicates the nature of the strips used in the test and their appearance after they are separated.

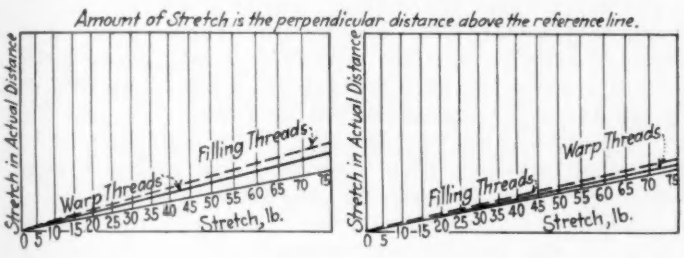

FIG. 6—STRETCH DIAGRAMS OBTAINED ON TWO SAMPLES OF TOP MATERIAL

You have all seen baggy tops that flap in the wind, sag and lose their trim appearance. The tendency toward this condition can be foretold by measuring the percentage of elongation under tension, by an autographic device attached to the fabric dynamometer. The jaws of the dynamometer are fixed 3 in. apart with the $1\frac{1}{4}$-in. clamps in place. The stretch is measured by actual distance above the base-line on the stretch-strain diagram and is recorded at 20, 40 and 60 lb. The samples are 6 in. long by 1 in. wide.

Fig. 6 shows the stretch diagram obtained on two samples of automotive top material. In one case the stretch is very high, amounting to about 9 per cent in the warp direction at a 60-lb. tension; in the other case it is less than one-half that amount. The test is, of course, very severe, and it is not to be supposed that an automobile top would ever be subjected to a force sufficient to stretch it 9 per cent. The figures obtained, however, are relative and it has been shown that the 9-per cent material is less satisfactory in actual service than the 4-per cent material.

The resistance to puncture is determined by a small steel foot that is pressed against the fabric, the force necessary to produce rupture being measured. The Webb testing-machine shown in Fig. 7 is fitted with a $\frac{1}{8}$-in. foot, which is used over the No. 1 hole. The goods are placed under the foot and held by a clamp in both the warp and the filling directions while the pressure required to puncture the goods is recorded. This instrument was designed originally to measure the breaking-strength of paper and strawboard. Various attachments that have been supplied with the device have made it suitable for measuring some of the qualities of leather-cloth. A flat 1-in. square foot that is furnished can be used to measure the resistance to cracking. It is not possible, however, to obtain so high pressures on the

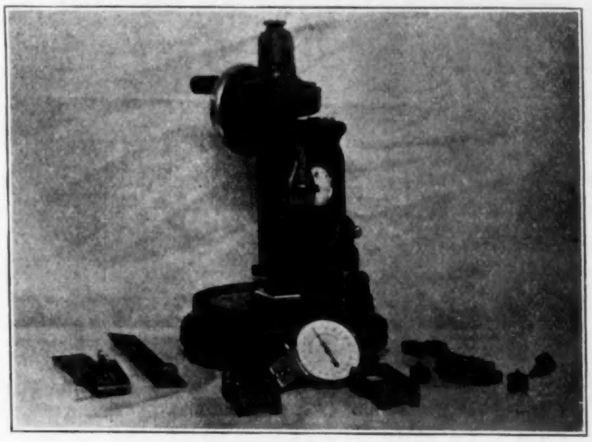

FIG. 7—THE TESTING-MACHINE USED TO DETERMINE THE RESISTANCE OF THE FABRIC TO PUNCTURE AND AT ITS SIDE THE GAGE FOR DETERMINING THE THICKNESS OF THE FABRIC

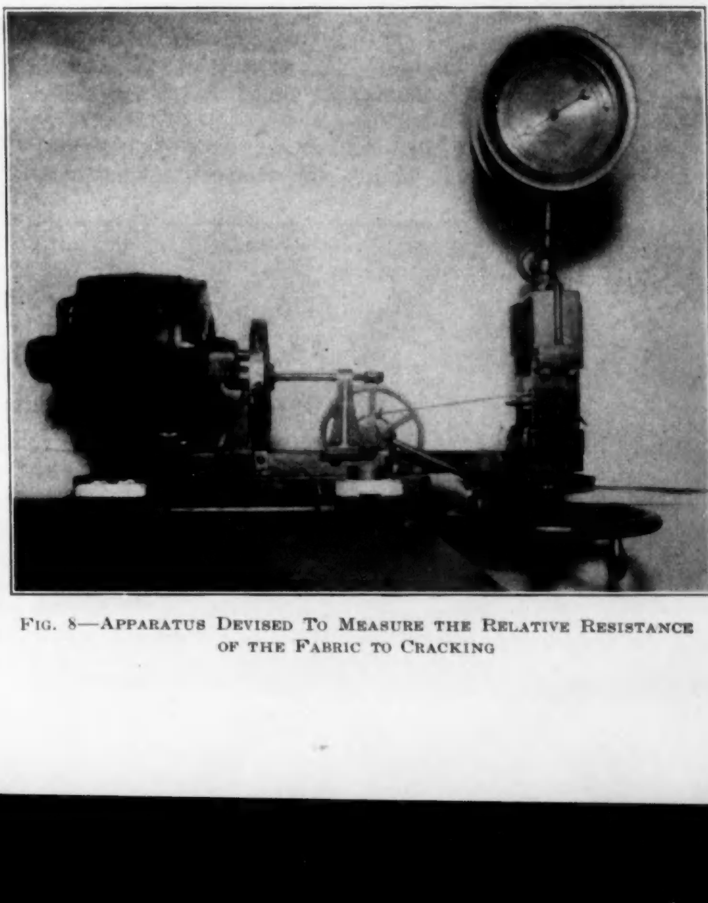

FIG. 8—APPARATUS DEVISED TO MEASURE THE RELATIVE RESISTANCE OF THE FABRIC TO CRACKING

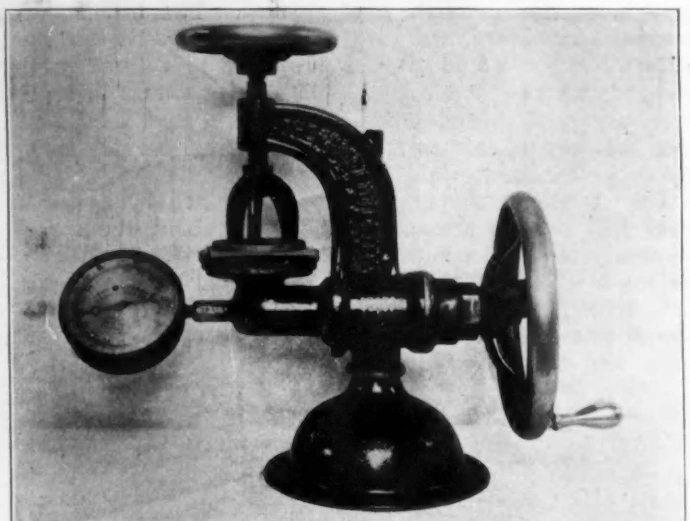

FIG. 9—TESTING-MACHINE TO DETERMINE THE RESISTANCE OF THE FABRIC TO WATER

water testing-machine shown in Fig. 8. In Fig. 7, alongside the Webb testing-machine, is shown an Ashcroft thickness-gage that is used for determining the thickness of leather-cloth.

The operations of folding and stitching will produce large cracks on an inferior material, whereas a high-grade product will withstand severe manipulation without injury. To determine the relative resistance to cracking the apparatus shown in Fig. 8 was devised. This instrument measures cracking pressures up to 200 lb. per sq. in. Many high-grade leather-cloths will withstand these easily. A few products are so brittle that they crack below a pressure obviously much too low to meet even the simplest manufacturing requirements. The test consists in taking strips 1 in. wide that are cut parallel to the warp and the filling of the base fabrics. These are folded into creases with the coatings up and placed beneath the foot of the testing machine. The pressure on the foot is gradually increased by rotating a handwheel until the coating cracks. The pressure is recorded by a diaphragm filled with water and connected with a pressure-gage.

The toughness of the coating sometimes is determined in a practical way by manipulating the goods between the fingers, in what is commonly called the "scrub test." There are a number of other so-called "hand-tests" that sometimes are used as a general guide. One of these consists of drawing some blunt instrument quickly across

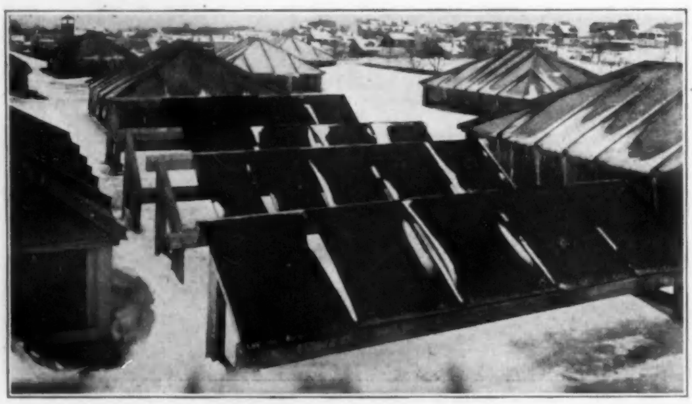

FIG. 10—DETERMINING THE LIFE OF THE FABRIC BY PLACING IT ON AGING BLOCKS ON THE ROOF

the coated surface; another is to fold the goods double and rapidly draw them apart. These tests are, of course, not more than general indications inasmuch as different persons do not perform them in the same manner.

In some cars that have been on the road for a little while you can see that the coating of the upholstery has peeled off in large pieces, the fabric beneath showing. In fact, the coating on some materials is anchored so poorly that it can easily be pulled off with a finger-nail. In a practical way, a general idea of the degree of adhesion can be obtained by the finger-nail test but it is far from exact and, of course, does not allow expression in numerical units. We have, therefore, designed an attachment to our crack testing machine to measure the adhesion properly and we recommend a method in which 1-in. strips of the goods to be tested are cut parallel to the warp and the filling threads. Near one end of each of these strips a flat S-bend is formed. A pressure of 1 lb. is then applied to the bend by the pressure jaws. The ends are fastened to a clip on the motor-driven revolving cylinder. The motion of the cylinder draws out the goods at a uniform speed. Various pressures are used until the minimum pressure at which the coating is stripped from the base is determined.

The importance of affording protection from rain is obvious in the case of topping and deck material. The relative resistance of various leather-cloths can be determined by placing a sample of the coated goods face-downward in the Mullen testing-machine illustrated in Fig. 9, after first removing the rubber diaphragm, filling the well with water and ascertaining the pressure necessary to force the water through.

Materials that have a very low degree of water-resistance can be tested by folding a piece of goods 20 in. square into a bag partly filled with heavy objects of irregular outline and immersed in water. The penetration after 24 hr. and again after 48 hr. is noted.

Several instances have occurred in which automobile tops have shrunk so badly that the bows have been pulled out-of-shape and loose from the frame. The shrinkage factor should, therefore, be predetermined. In making this test lines are ruled 10 in. apart on the sample which is then soaked in water at room temperature for 1 hr., drained and hung up vertically to dry. When it is completely dry, the distance between the lines is measured and the contraction is expressed as a percentage of the length.

It is, of course, not possible by any process to convert cotton or any organic substance into asbestos. It is desirable, however, that the coating material be not highly inflammable. The relative fire-resistance can be determined with strips that are cut 1 in. wide by 8 in. long and supported vertically so as to hang freely. One of the lower corners is ignited with a match and the time from the application of the match to the complete combustion of the strip is determined. This will include the time-interval for ignition as well as for combustion. The condition of the cinder and the rapidity of travel of the flame are noted.

A considerable variation among the numerous commercial brands of leather-cloth in their properties of heat-resistance exists. Some are affected very little by summer heat, whereas others "sweat" very badly when slightly warm. This "sweating" or "spewing" is very objectionable. To test fabrics for this characteristic the samples should be placed within a constant-temperature oven, adjusted to 150 deg. fahr., and allowed to remain for 2 hr., after which they are examined for tackiness and sweating. They are then allowed to come to room

temperature and are examined for any change in flexibility and permanent change in toughness.

To determine the ease with which it can be cleaned, the coating should be subjected to a practical test by washing small strips of it with soap and water and also with gasoline. There should be no appreciable loss of luster or injury to the coating. An alternative test in the case of laminated leather-cloth, or of the two-ply khaki top-material, is to soak it in gasoline for 24 hr.; after drying it no difference should be found from the condition of the original sample in either the bonding or the tensile-strength.

The final criterion of quality is how the goods stand up in service. It takes a long time for goods to deteriorate under the natural influence of sunlight, wind, snow and rain, when placed on aging blocks on the roof as shown in Fig. 10. To determine the relative merits of various fabrics quickly it is possible to expose the samples to the ultra-violet rays of a mercury-arc light, illustrated in Fig. 11, and obtain information in a few days that ordinarily would require several months, showing both the deterioration of the coating and the stability of the color of composite cloths.

The effect of exposure on the water-resistance is shown at the left of Fig. 12. These curves indicate how the water-resistance of a few of the samples decreased during the test. The curves of the center denote the gradual loss of flexibility and the stiffening-up with age, and those at the right show the gradual loss of toughness of a few of the samples. At the end of the year some of them were as cracky as a fountain-pen and would snap when lightly pinched between the fingers.

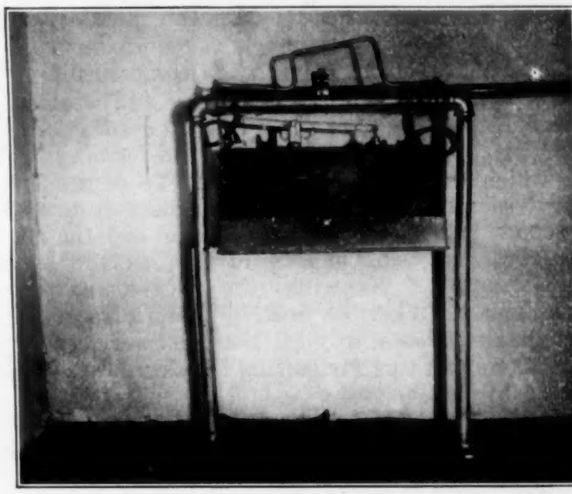

Fig. 11—Mercury-Arc Light Used To Determine the Life of the Fabric

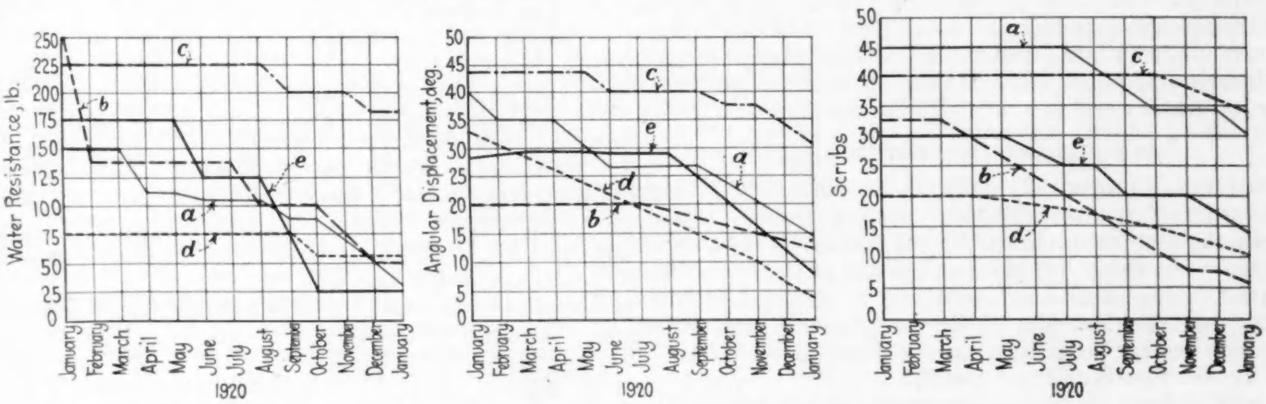

Fig. 12—Curves Showing at the Left the Effect of Exposure on the Water-Resistance, in the Center the Gradual Loss of Flexibility with Age and at the Right the Loss of Toughness

Maintenance of Uniform Quality

The numerous properties have a wide variation among the different brands. To guard against fluctuations so that goods of uniformly high quality may be produced, it is necessary that the manufacturers take great precautions against defects in the finished material. In the case of the untreated raw material, the quality is assured by chemical analysis, and the uniformity of the treated products is maintained by careful control of the chemical and physical properties. The Doolittle viscosimeter, shown at the left of Fig. 13, has been modified to meet our particular requirements. The viscosity is determined by measuring the friction-resistance between the oil and a brass spindle.

TABLE 2—SKIN PROPERTIES OF OILS AND LACQUERS

Skin No.	Strength, Grams	Stretch, Per Cent
23	1,330	14
24	1,610	8
27	695	96
30	2,100	24
46	400	80
51	2,100	39
53	2,990	77
72	1,400	45
77	7,435	5
78	6,230	7
79	8,000	8
83	3,100	31
86	300	64
94	235	69
187	3,400	99

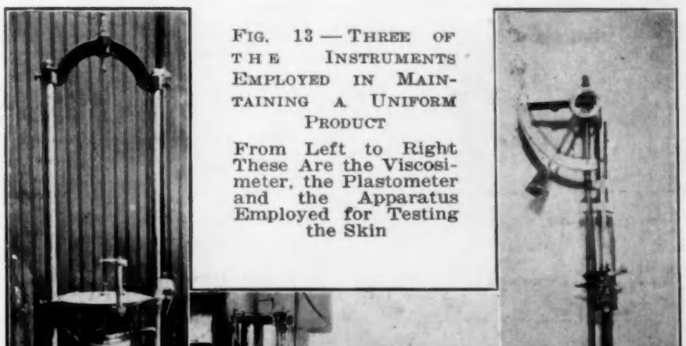

Fig. 13 — Three of the Instruments Employed in Maintaining a Uniform Product

From Left to Right These Are the Viscosimeter, the Plastometer and the Apparatus Employed for Testing the Skin

The plastometer, illustrated in the middle portion of Fig. 13, is utilized to maintain the uniformity of some of the primary mixtures that are compounded to make the coating. The strength, elasticity and wearing qualities of leather-cloth are dependent to a considerable extent upon the character of the skin-forming material with which they have been coated. To obtain strength without sacrificing pliability, it is necessary to maintain the proper balance between the fabric and the coatings. The fabric must be chosen to furnish the necessary tensile-strength. Knowing the weave, construction, weight and the like, the coating materials can then be selected scientifically to yield the most serviceable products. The apparatus for testing the skin is shown at the right of Fig. 13.

Table 2 shows the variations in the skin properties of a few typical treated oils and emphasizes the necessity for choosing the proper materials carefully to obtain the desired qualities in the finished product. A microphotographic outfit, by which skin-forming properties are studied, is illustrated in Fig. 14. Fig. 15 is a microphotograph of oils showing two different stages of treatment. The skins formed from various coating vehicles do not in themselves possess the desired characteristics of strength and wearing quality. To increase the resistance to wear and at the same time meet the artistic requirements in color and finish, certain pigments must be incorporated into the mixture. These are purchased on specification and are carefully checked for uniformity.

Specifications for Leather-Cloth

To produce motor cars with all the features of design and construction carefully balanced and to give the purchaser the maximum return for his money, definite specifications for many of the mechanical parts have been adopted. The steel must conform to definite requirements; the instruments must meet certain tests; yet very few leather substitutes are purchased according to any agreed specification of quality.

Specifications covering three general applications of leather-cloth to special requirements are presented below:

PURCHASE SPECIFICATIONS FOR AUTOMOTIVE MATERIALS

Kind of Material	*Top*	*Upholstery*	*Special Coach*
Tensile-Strength of Warp, lb.	175 to 190	195 to 210	120 to 130
Tensile-Strength of Filler, lb.	95 to 105	150 to 160	115 to 125
Weight per Square Yard, oz.	20 to 21	23 to 24	22 to 23
Thickness, in.	0.0320 to 0.0330	0.0360 to 0.0330	0.0350 to 0.0360
Toughness of Warp	30 to 40 (*a*)	40 to 50 (*a*)	200 (*b*)
Toughness of Filler	25 to 35 (*a*)	30 to 40 (*a*)	200 (*b*)
Resistance to Heat at 150 Deg. Fahr.	OK	OK	OK to Slightly Tacky
Resistance to Abrasion at 2,000 Rubs	OK to Slightly Dull	....	OK
Resistance to Abrasion at 3,000 Rubs	....	OK	....
Resistance to Abrasion at 4,000 Rubs	Slightly Dull to Dull	Slightly Dull	....
Resistance to Cold at 30 deg. Fahr.	No Cracking	No Cracking	....
Resistance to Fire, sec.	35 to 40	35 to 40	35 to 40
Cleansability with Soap	OK	OK	OK
Cleansability with Gasoline	OK	OK	OK to Slight Effect
Stretch of Warp at 20 Lb., per cent	0.75 to 1.00	1.50 to 2.00	2.00 to 2.50
Stretch of Filler at 20 Lb., per cent	1.50 to 1.75	4.00 to 4.50	4.50 to 5.00
Stretch of Warp at 40 Lb., per cent	1.00 to 1.50	2.00 to 2.50	3.00 to 4.00
Stretch of Filler at 40 Lb., per cent	1.75 to 2.00	5.50 to 6.00	6.00 to 6.50
Stretch of Warp at 60 Lb., per cent	2.00 to 2.25	4.00 to 4.50	9.00 to 11.00
Stretch of Filler at 60 Lb., per cent	2.00 to 2.50	8.50 to 9.00	8.00 to 9.00
Adhesion of Coating, lb.	4 to 5	5	4 to 5
Bonding Strength, lb.	2.50 to 3.00	2.50 to 3.00	2.50 to 3.00
Dryness	Good	Good	Good
Flexibility	OK	OK	OK
Resistance to Shrinkage of Warp, per cent	1.00 to 1.50	0.50 to 0.75	0.75 to 1.00
Resistance to Shrinkage of Filler, per cent	0.25 to 0.75	0.00 to 0.25	0.00 to 0.25
Smoothness	Good	Good	Good
Fabric Construction	Muslin and Drill	Muslin and Drill	Muslin and Drill
Thread Count, Muslin	62x50 to 66x58	66x60 to 64x58	52x50 to 48x46
Thread Count, Drill	62x34 to 66x40	109x46 to 107x44	72x60 to 68x56
Resistance to Puncture of Warp	325 to 350	330 to 340	200 to 210
Resistance to Puncture of Filler	285 to 315	380 to 390	250 to 260
Water Resistance for 48 Hr.	OK	OK	OK
Water-Pressure Resisted, lb.	80 to 120	200 to 250	240
Surfacing	Good	Good	Good
Luster	Standard	Standard	Standard

(*a*) Determined by scrubbing test.
(*b*) Determined by water test.

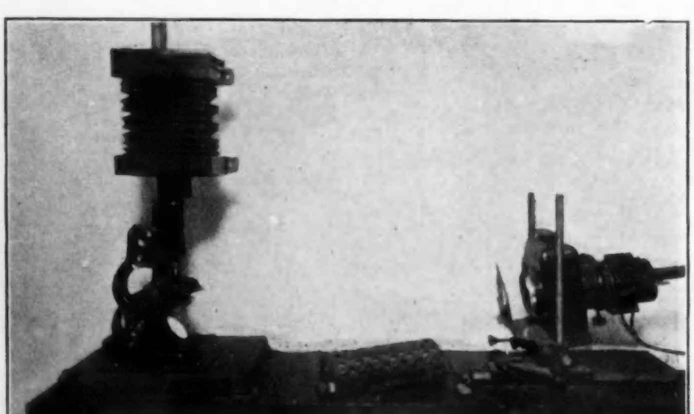

Fig. 14 — Microphotographic Outfit Employed To Study the Skin-Forming Properties

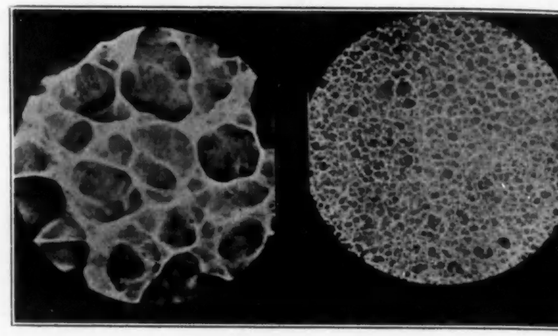

Fig. 15—Microphotographs of an Oil Showing the Results of Two Different Treatments

Maintenance Effects of Automotive Electrical-Equipment Standardization

By A. H. PACKER[1] CHICAGO SERVICE MEETING PAPER

THE author outlines past conditions that led to a diversity of design for similar parts, such as tires and rims, as being analagous to the causes of present variations in automatic electrical equipment intended for identical purposes, and gives specific instances in which such variation has resulted in excessive expense and delay.

Constructive suggestions are made for improvement in regard to reducing the number of types of equipment and standardization of the remaining types, more especially with regard to generators, as a means of making possible better service-station efficiency and a reduction of the investment now necessary because of the carrying of an excessive number of parts in stock. Standardization problems are stated and commented upon, and the advantages of a reasonable degree of standardization for electrical equipment are set forth.

TO get a vision of how present difficulties might have been avoided, let us start at the time when pneumatic tires were first being developed, and pretend that at that time there was the same amount of engineering initiative that we have in the industry today. Tire companies and motor-car companies were many, and none of them would consider having any part so common that it could be used on any other car. Accordingly, it happened that each motor-car company designed wheels having rims that required special tires. No two different makes of car could use the same size of tire, and the tire companies bowed to the wishes of their prospective customers and designed accordingly. Some cars required different sizes and types of tire on front and rear wheels; on others, designers thought that, due to the crown of the road, the tires on the right side should be larger, with the ones on the left side made oversize for foreign shipment.

After these companies had distributed several million cars to purchasers uninformed as to the real meaning of variations of this kind, tourists often had the experience of being stranded while waiting for a tire from the factory because, unless the local dealer handled that particular make of tire, there was no chance of getting some other make to fit. Each motor-car company continued to justify itself regarding this policy by the fact that customers had to come to it for tires, forgetting that it was automatically closing its doors to the possibility of a great amount of additional replacement business. Some of the smaller tire companies went out of business, but the larger ones could not profit by this because they had nothing to sell the former customers of the other organizations. Nor was this the only way in which the whole industry was limiting itself. Prospective buyers hesitated to buy cars because blowouts of tires might necessitate expensive hotel bills while waiting for a new tire or the abandonment of the car and returning home on a railroad train. Such negative advertising passed from one car-owner to another and increased sales resistance so that competitors were forced to get together to see what was wrong and try to correct it; and this is the point at which we find ourselves today.

The foregoing outline is a close parallel to the condition that exists today in regard to automotive electrical-equipment. Not only do we have a multitude of starting motors, generators and ignition devices, that fit on one car and one car only, but we have wiring schemes that have very different arrangement on the car, although they are the same in principle. This is a source of annoyance not only to the owner of the car but to the average man in the small electrical station as well. A man in a small town does not have a sufficient quantity of work to make him familiar with the wiring on all of the various makes of car. However, if the circuits were analyzed, we would find them essentially the same; accordingly, it would seem possible to get some systematic way of wiring all cars.

For example, the tail-lamp wire might be designed to run back along the left side-rail of the frame or body; a standardized location of the fuses would help; a standardized color scheme for the wires, long discussed, would facilitate trouble-shooting; and a definite location for the terminals on the back of the lighting-switch would make it easier for all concerned. This would mean, for example, that the tail-lamp terminal would always be at the bottom, the head-lamp terminal always at the top and the battery terminal always in the center. Then an electrician could locate wiring or circuit trouble on any car more quickly and easily, and the customer would have just that much more satisfaction from his car. Regarding standardized color-schemes, a certain magneto made some years ago had a cable from the magneto to the coil, the three wires being colored red, green and yellow and the terminals on the coil marked *R*, *G* and *Y*; the average man thus was able to get the wires on the right terminals.

An endeavor has been made to improve the available facilities for training men for maintenance work because the present schools are inadequate. This takes time, but we can improve conditions in automotive maintenance by making the various jobs easier as well as by making the workman more skillful. At present it is a gamble as to what will happen to a car if some small-town battery or electrical man is asked to locate trouble in the wiring. Occasionally, a good man at this work is found, but this is not the rule. Few so-called electricians know the fundamentals of the wiring of cars sufficiently well to shoot trouble on an unknown model, and the variation in the wiring plans is so great that it is impossible for any man to memorize them. Nor do wiring manuals help out in every case. One reason is the cost, which prevents all but the most farsighted from using this kind of assistance. Others do not use diagrams because they do not know how to read a blue-print; the lines on the paper mean nothing to them so far as tracing the wires is concerned. This class of man is working on the cars we build and, whether we acknowledge it

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or not, he is our agent in the eyes of the car-owner. Whatever trouble he causes and whatever mistakes he makes in working on our customers' cars, he will never ascribe them to his own inability but will blame the manufacturer for putting out a pile of junk and making a mess of the wiring. Such things do not promote sales; they kill them. That is why, in self-defense, we should standardize wiring so that, if a man had ever traced the tail-lamp circuit on any car, he could go to any other car and trace the same circuit with equal facility. Variation in wiring schemes makes maintenance difficult but not impossible. On the other hand, the variation that exists in the construction of the electrical equipment on the car cannot be overcome by any amount of training that the electrical man might have. The expense that this entails is borne by the automotive industry.

To illustrate what special design really means, some years ago, when working for an electrical company, my time from 3:00 to 10:00 p.m. was taken up in reaching a small town where a job awaited me. The local powerhouse was operated overtime for $1\frac{1}{2}$ hr. to provide light in the garage, through influence, only to find that the car in question was equipped with an ignition generator different from that used on any other car, that nothing in an ordinary garage would replace it and that no near-by town garage or dealer could help out. Even when it was customary to render service of this kind, it showed a condition that is far from right. Someone must pay for expensive maintenance of this nature. If the factory stands up under such strain, it is due to the fact that the expense has already been passed along to the customer by increasing the first cost of the equipment.

Even today conditions in this respect are not appreciably improved. I visited a small battery-station recently, in a town about 30 miles from Chicago. While I was there a man came in to see about a generator he had left for repair. Examination had shown that it needed an armature, bearings and brushes. The shop did not have these, nor was there any place nearer than Chicago where they could be had. The generator, as usual, was used on that particular car only, and the parts could not be obtained within 4 or 5 days. In the case of this particular car, it was possible to run without the generator being in place; but, if it had been a car on which either the oil-pump or the water-pump was driven through the generator, or ignition apparatus was mounted on the generator, the holdup would have been complete. The average service-station in a small town has small chance of having in stock whatever part a car-owner may need. In checking-up a wiring manual recently, I found listed therein 791 diagrams of different cars, 14 different generator makers in active production and 171 different types of generator made by these companies.

Proposed Service Improvement

The Automotive Electrical Association proposes to establish stations throughout the Country which will handle service on all makes of electrical equipment. This is a step in the right direction, but how can it possibly succeed in doing this where the community is so small that the sales will not pay the interest on the stock investment? In a small electrical service-station not far from Chicago, two partners are working their heads off and claim to have over $8,000 worth of stock. They told me about what sums they were able to draw out of the business each week. I figured that if they subtracted the interest on their investment they would find they were making less in a week than they could easily get if working for someone else. These men are subsidizing the industry to the extent of their investment; they do not realize it. If this same station were handled by a business man capable of figuring his interest, depreciation of equipment and kindred factors, he would find it necessary in a small community of this kind to increase prices so that these overhead items would be taken care of. The burden would then fall on the car-owner, just as it does now, but it would be a cash burden rather than one of inconvenience.

Another example of extreme inconvenience caused by the lack of uniformity in electrical equipment is shown by the experience of a man who was driving from Milwaukee to Chicago. He was passing through one of the small towns near Chicago, when his car suddenly stopped. He called on an electrical service-station and it was found that the distributor-arm in the battery-ignition system had been punctured. The electrical station acted as official service agent for one or more makes of equipment but not for the one in question, and the man had to abandon his car. Now there is no patent on the shape of the upper part of a distributor-shaft, and there is no reason why there could not be some uniformity as to the radius through which a distributor-arm swings. Except that distributor-arms of various makes do not fit in place of each other, they are very similar, and there seems to be no reason why they could not eventually be made interchangeable. Such a suggestion will, no doubt, be objected to by a number of engineers, but advancement in any line is attained only by subordinating personal opinions to the good of the many. If the present S.A.E. Standards were more generally used, this man would not have been forced to leave his car. In an emergency, a busy man probably would prefer to buy a whole distributor of another make, rather than lose the use of his car for several days. But even with the best of standards, well worked-out by wise committees, there will be no appreciable benefit to cars already in the user's hands. However, the industry is progressing. We must work for the period 10 years hence, or our anticipated progress will fail to materialize.

Standardization Problems

How shall we begin to standardize? A proposed basis, taking into consideration the electrical characteristics of the machine, has been outlined, but how will this help the maintenance shop unless the mechanical dimensions also are determined? And, if both the electrical characteristics and the mechanical dimensions are predetermined, are not some of our engineers right when they say that standardization would remove all chances for initiative and for development in the art? We would be on a war basis, building for production only according to planning already done.

The car-owner and even the service-station proprietor do not care much whether a generator charges a battery at 12 or at 14 amp. Furthermore, if it does charge at 12 amp., that may be too much for the way some cars are run and 14 amp. may not be enough for other classes of usage. Of course, if a generator charges only at 5 amp. and the battery has to be charged every 2 weeks, someone will let us know about it. On the other hand, if the generator is one of the ultra-enthusiastic kind and has a propensity for throwing out solder and loosening its armature leads, there will also be a comeback; but, in between these extremes, the exact charging-rate is not so vital as engineers would lead us to believe.

On the other hand, suppose we should proceed with

the standardization after the following fashion: Make a survey of generators now in production that have an output of say 12 amp. at 8 volts at 1500 r.p.m. without destructive heating; take a number of such generators and consider their length and diameter; consider the length and diameter of the armature core, the size of the commutator and the brushes, the size and location of bearings, and lay-out a standard generator on this basis. We now have the mechanical dimensions pretty well-defined, but they have not limited initiative. Perhaps some particular electrical-equipment company that has extensive research facilities will develop a grade of iron in which the heat losses will be less than those in commercial laminated steel. By this means it may be able to put out one of these standard machines that will either have a greater output at the same temperature, or have a lower temperature for a specified output. In either case the company purchasing such a machine would get more for the money, or that machine might be sold for more than the average standardized machine. Perhaps some other similar company would develop a new type of insulation that would withstand excessive heat, due to overloading or overspeeding; it might thereby have a product superior to that of some other companies.

Standardization of complete machines would be a step in the right direction. It would make possible the use of a rental machine while the machine from the car was being repaired. However, by visiting a number of service-stations, it will be found that, as a rule, no attempt is made to keep complete machines in stock. The present reason is their high cost, combined with the fact that it is impossible to have enough different kinds of machine to fit all cars. Then again, as a rule, the customer does not wish to pay enough to have a complete machine put on, except in very unusual circumstances.

About the most common part carried in stock is the armature. While the cost of this is, of course, not so much as that of a whole machine, it is enough to prevent all but the very largest establishments from having a sufficient variety of armatures to handle the general run of cars. It seems that standardization of armature sizes would be of the greatest benefit to the electrical-maintenance division of the industry. It would require fixing bearing dimensions and their relation to the armature core and commutator. The size of the core, both the diameter and the length, would have to be set, and the commutator size would have to be fixed. Here, of course, we run into questions of design. In a machine of fixed external dimensions, one engineer might figure some advantage in a fairly large armature, with less space for the fields, while another engineer might favor a smaller armature with greater field-space. It appears, however, that an analysis of a number of machines would determine average dimensions that could be adhered to. It may be said that, even if an A-type machine is standardized so that the armatures are all alike in regard to external dimensions, they may not be interchangeable electrically. That may be true at the start, since we have four-pole machines and two-pole machines, but it should be possible to settle on one of the types as standard. In fact, most of the generators now in use are four-pole machines. In regard to the manner in which armatures are wound, it makes little difference whether progressive or retrogressive winding is used, if all armatures use the same method of winding. Even if engineers should insist on their right to individuality in this particular respect, it would be easy for the service-man to reverse the fields and make the armature suffice.

The question of brush position also is one that would have to be settled before an armature would be interchangeable with that of some other type of machine. Here again the fundamental nature of the winding is determined by electrical laws that no engineer can alter. The brush must be placed on the commutator so that it rests on commutator bars connected to coils that are generating little or no voltage at that instant. From bars under a brush, the winding invariably goes to a point between the poles. If the brush is located under the pole, it must go off to one side a little more than half the pole width. In the other direction, the winding also goes off at an angle for about half the pole width. The other possible brush position is between the poles. In this case one armature wire must go straight up to get into the neutral zone, while the other must go over at an extreme angle the distance of the whole pole-width and a little more, to get into the next neutral zone between the poles. The point is that the electrical operation in one case is the same as in the other, and special armatures would have to be made for each type. There is, however, no reason why all such machines could not have the center of the pole as the standard main brush position. Regarding what latitude this would give the designer and wherein he would have a chance to develop his product, variation in the number of commutator bars would still be permissible if the diameter were kept the same. Variation in the slots, in the quality of the iron, and in the relation of field ampere-turns to armature ampere-turns would still be possible, so that we would continue to have machines differing somewhat in electrical performance. Perhaps some, more expertly designed, would have better commutation and therefore have greater brush-life.

It may be said that the interchangeable feature for an armature would have little value if the electrical characteristics were not identical but, according to my experience, this is not the case. To show how it is possible to take liberties with the design of a machine and still make it work, while in charge of a certain service-station I received a telegraphic order for a generator to be sent to a tourist in Canada, whose machine had quit. The machine on the car in question was a 12-volt generator, and all we had in stock was a 6-volt machine of the same size. This was modified, so far as protecting its field was concerned, by installing a quickly made resistance unit, equal in value to the shunt-field resistance. The regular 6-volt armature was used for this 12-volt machine, and it worked all right. This generator came back, in about 6 months, not because the idea was not all right for an emergency, but because the resistance unit had been mounted inside, where it did not cool sufficiently, and it had eventually burned-out. This illustration is an extreme case, for the run of 6-volt armatures do not differ nearly so much as was true in this instance.

Any car-owner would rather have an armature put in that charged at 2 amp. less, than wait 2 days for some other kind. Again we have found that, even if one armature has seven turns per coil and another nine turns, they can be interchanged without much trouble. Third-brush adjustment is capable of giving approximately the same results in either machine. If the armature with few turns were put into the other machine, the brush could be advanced slightly; if the opposite were true, the brush could be moved back somewhat. It is interesting to note that the 15 makes of car that are in heaviest production all use generators having the third-brush method of regulation.

About 150 kinds of generator armature must be kept

in stock at present. Many of these armatures are so nearly alike that careful examination is needed to determine their differences. Two of these made by one company are identical except that the diameters of the shaft-end on which the sprocket goes are different. It is probable that when the sales department solicited orders for a certain machine the purchasing agent's reply was to the effect that he had several thousand sprockets in stock that could not be used on the department's regular machine, but that the same generator made with the shaft size to suit those sprockets would secure the order. Thus the special armature came to be made, to be a burden to service-stations ever-after.

Assuming that we could equip cars at present with standardized machines only, and that within 10 years the present cars would have had their present generators replaced with standardized generators, we would have reduced the number of types of armature in stock from 150 to 5. Let us say that there are 1500 electrical service-stations that are carrying at least a full set of armatures and that the average dealer's price on these is $10 each. On this basis we have a minimum investment of $2,250,000. Furthermore, this is only on a basis sufficient to take care of one customer on any particular armature. Now if we assume that the 10-year period of readjustment has passed, we find the investment reduced to $75,000, a difference of $2,175,000. Not only is this enormous reduction of investment possible throughout the Country, but any small battery or electrical station having $50 to invest can acquire a stock of five armatures that will take care of any job that may come his way. At present such a thing is entirely out of the question. This $2,175,000 represents some $130,500 saved in interest. If we take Ray Sherman's figures of 10-per cent average total net-profit as being just, we find that a business of $1,305,000 would have to be done to accomplish as much. Let us remember that these figures are based on generator armatures only, no motor-generators or starters having been considered. If these also could be standardized, the saving could be more than doubled. The calculation was made on a basis of only one armature of each kind in stock, whereas most stations carry a number of the more popular types.

It is impossible to measure in dollars the value of such a condition to the automotive industry. For example, in case of a fire or a strike that might tie-up a large electrical plant, other equipment would be available and might even be secured by this plant to satisfy its customers and keep its business. Again, having parts available in all regions of the Country instead of in the larger centers only should give such satisfaction to car users as to react in greatly increased sales and prosperity for the whole industry. There is no great agitation in the spark-plug field in favor of 150 different types of thread instead of some three or four, or any agitation in favor of 150 different types of plug and socket for lamp fittings. We have two types now, and that is one too many. Standardization of those parts has not cut into anyone's business, but has made possible increased production, sales and profits.

THE EDUCATION OF ENGINEERS

SCIENTIFIC knowledge is not the only ingredient necessary for the making of an efficient engineer; and although knowledge of ascertained fact is required, and in the fullest possible measure, in order that it may be employed as a basis for projected designs, the knowledge likely to be most valuable as giving clear vision in these respects is that full comprehension of plain physical reality which enables a man to form a reliable prediction as to the probable consequences of a proposed action, and to trace backward accurately from an observed result to the causes of which it is the effect. Engineering deals always and solely with actual physical realities; and the mathematics of engineering must be taught and studied throughout in terms of physical reality if the school work is to form a suitable foundation upon which the real education of an engineer may be built.

The activities of the human mind may be classified under three broad headings: (*a*) imitative, (*b*) interpretative and (*c*) originative. Such a classification is already recognized, tacitly, at least, but the fatal error is made of attempting to apply the classification to individual minds instead of to the activities of each and every mind. In such imitative work as the manufacture of ordinary sewing-needles there is wide scope for the exercise of both the originative and interpretative faculties. In the essentially interpretative work of the ordinary commercial drawing-office and machine-shop there is of necessity much that is almost purely imitative, while there is also need for originative ability without in any way encroaching upon the preserves of design. And in the originative work of design, administration and organization there is inevitably much that is imitative, and also very much that is truly interpretative.

It would be difficult, if not impossible, to define the precise boundaries between any two of these fields; and it would appear unlikely that any useful purpose would be served by such definition. All three should be cultivated and developed, with equal assiduity and care, in each and every mind, for all three are of equal importance, instead of endeavoring to produce here and there a few minds that shall give out original ideas constantly and exclusively; and a few others that shall do nothing but interpret the ideas originated by their superiors; while the main bulk are left to wallow in mere imitation. The latter course has been followed for a long time and is now obviously found wanting, a result that is not surprising, seeing that the method is altogether unnatural.

It is, of course, true that the higher ranks of the profession are concerned with originative work to a greater extent than are the lower ranks; and that, consequently, personal progress in it must be upward from work that is mainly imitative through that which is mainly interpretative. But no argument is needed to show that every individual member of it, as well as the profession as a whole, would benefit enormously were the fact recognized and made clear to all that, throughout life, the three faculties are all of equal importance in each mind, and should be cultivated and developed with equal care; that work which is apparently of the most imitative character demands the exercise of the interpretative and originative faculties if it is to be really well done, and that it is impossible for a man to originate any truly good project unless his imitative and interpretative faculties be thoroughly keen and well developed.—E. G. Beck in *Engineering* (London).

Further Data on the Effective Volatility of Motor-Fuels

By ROBERT E. WILSON[1] AND DANIEL P. BARNARD, 4TH[2]

ANNUAL MEETING PAPER *Illustrated with* DRAWINGS AND CHARTS

SINCE the authors presented a paper on the subject that included the test results of only three fuels, the number of fuels investigated has been increased to 14 and several improvements have been made in the method relating to the manner of the preparation of the equilibrium solution and in the apparatus used for the measurement of vapor-pressures.

In addition to describing these improvements, the present paper includes data on the fuels; a series of empirical curves from which it is possible to determine, aided by the data from the distillation curve, the dew-points of non-aromatic hydrocarbon fuel; a table showing a comparison of the more important properties of the fuels; and definite evidence that the 85-per cent point is the best single measure of the effective volatility of a motor-fuel, from a standpoint of distribution and crankcase dilution.

IN a previous paper entitled Condensation Temperature of Gasoline and Kerosene-Air Mixtures[3], the authors presented a new method for the measurement of the dew-points, or initial-condensation temperatures, of motor-fuels when mixed with air in various proportions. At that time the experimental work had been confined to three fuels, Socony kerosene, Socony gasoline, and an artificially prepared high-end-point gasoline. Since then, however, the number of fuels investigated has been increased to 14, much of this work being done in connection with the cooperative fuel research program conducted jointly at the Bureau of Standards by the American Petroleum Institute and the Society of Automotive Engineers. The larger number of fuels now includes specimens ranging in volatility from the lightest fighting-grade aviation gasoline to a rather high-boiling commercial kerosene.

Since the presentation of the first paper, several minor improvements have been made in the method, chiefly in the apparatus for the preparation of the equilibrium solution and that for the measurement of vapor-pressures. The more extensive data have also made possible the development of a series of empirical curves from which it is possible to determine with a fair degree of accuracy the condensation temperatures of an ordinary motor-fuel from the data given by the standard distillation-test.

This paper contains (*a*) certain modifications and improvements in the method developed previously by the authors for preparing equilibrium solutions and the measurement of the vapor-pressures of motor-fuels; (*b*) data on the effective volatility of 14 different fuels, covering a very wide range of volatility; (*c*) a series of empirical curves from which it is possible to determine the dew-points of a non-aromatic hydrocarbon fuel, aided by the data from the distillation curve, with a degree of accuracy sufficient for all ordinary purposes; (*d*) a table showing a comparison of the more important properties of the fuels investigated; and (*e*) definite evidence that the 85-per cent point is the best single measure of the effective volatility of a motor-fuel, from a standpoint of distribution and crankcase dilution.

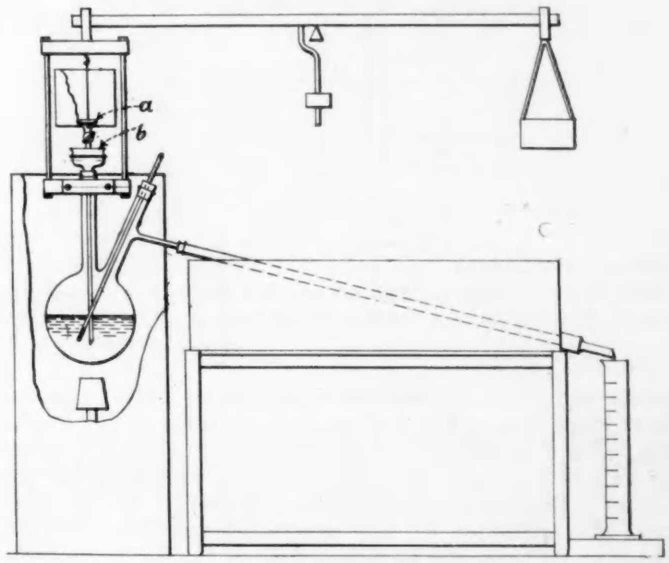

FIG. 1—AUTOMATIC FORM OF APPARATUS THAT HAS BEEN DEVELOPED FOR THE PREPARATION OF EQUILIBRIUM SOLUTIONS

EQUILIBRIUM-SOLUTION PREPARATION

The experimental work involved in the determination of condensation temperatures divides itself into three steps: (*a*) the preparation of a mixture known as the equilibrium solution and which has the same composition as the first drop of liquid that would condense from the dry vapor on gradual cooling; (*b*) the measurement of the vapor-pressures of this solution and of the original fuel; and (*c*) the standard Engler distillation-test on the fuel. The last operation furnishes the data from which the *approximate* average molecular weight is determined.

The first step involves the distillation of the fuel under such conditions that fresh fuel is supplied to the flask at the same rate at which the vapor is being condensed, the distillation being continued until the temperature becomes constant and the incoming and outgoing liquids have the same composition. To obtain equilibrium requires from 1½ to 3½ hr. It therefore becomes desirable to construct an automatic device that will maintain a constant level in the distillation flask, and eliminate the necessity of the continual attention of an operator for this considerable period of time. Such an apparatus, shown in Fig. 1, has been constructed in the laboratory of the Massachusetts Institute of Technology. The apparatus consists of a distillation flask having two

[1] M.S.A.E.—Research engineer, research laboratory, Standard Oil Co., Whiting, Ind.

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[3] See THE JOURNAL, November, 1921, p. 313.

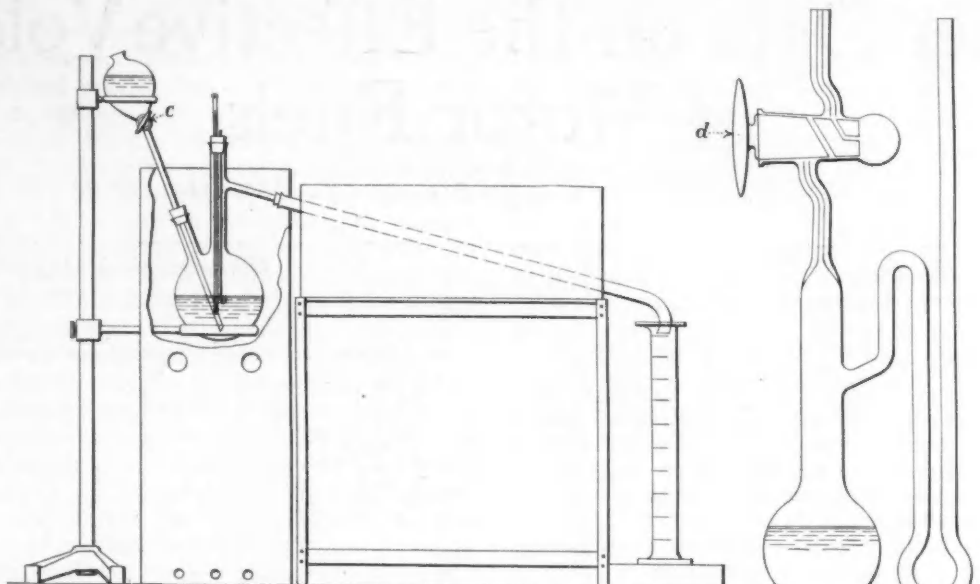

FIG. 2—ANOTHER FORM OF APPARATUS FOR PREPARING EQUILIBRIUM SOLUTIONS AT THE LEFT AND AT THE RIGHT THE VAPOR-PRESSURE BULB WITH A SPECIAL FORM OF CAPILLARY VACUUM STOPCOCK

necks supported at the end of a balance beam. As the flask rises, due to the boiling away of some of the liquid, the valve *a* is opened and admits fresh fuel. The escape of vapors through the supply tube is prevented by the use of a flexible paper diaphragm shown at *b*. In practice, the operation of this apparatus was very steady, showing no tendency to admit fuel in "slugs." The last portion of the distillate collected after the equilibrium temperature had been reached gave almost identically the same distillation-curve as the original fuel, provided care was taken to condense the vapors completely. The use of the two-necked flask was resorted to to avoid the fractionating effect of the incoming cold fuel on the hot vapors, and also to simplify the construction of the apparatus.

[4] See Physikalische-Chemische, Tabellen, 1920 edition.
[5] See Properties of Saturated and Superheated Steam, by L. S. Marks and H. M. Davis, 1909.

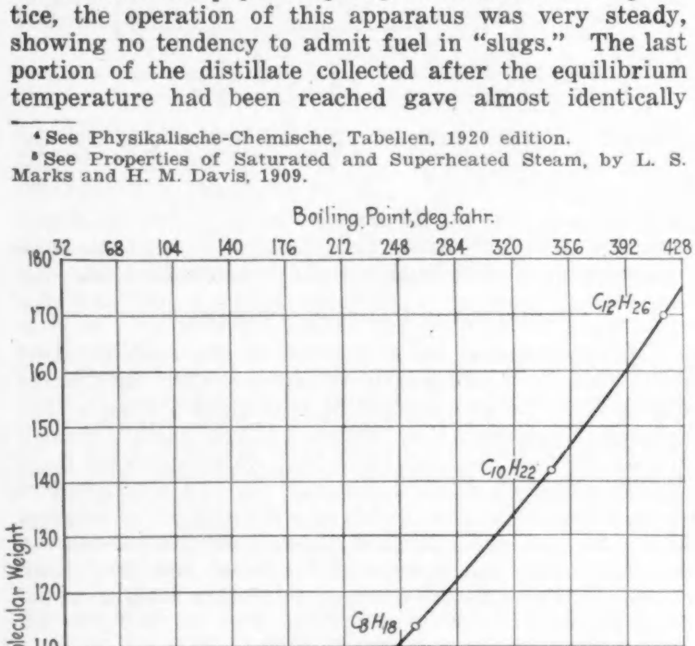

FIG. 3—RELATION BETWEEN THE MOLECULAR WEIGHT AND THE BOILING-POINTS FOR SATURATED PARAFFIN HYDROCARBONS

A second apparatus also has been devised, as shown at the left in Fig. 2. In this scheme also the two-necked flask is again used, coupled with the condenser used in the standard distillation-test. The rate of feed of fresh fuel is controlled by the manually operated stopcock, *c*. It has been found that this arrangement requires the attention of the operator but once in every 10 to 15 min. The use of the oil heating-bath has been discontinued in both cases, as a properly shielded direct gas-flame gives much steadier operation and less bumping.

Most of the equilibrium solutions used in the following measurements were prepared in this latter type of apparatus and, in each case, the last sample of distillate was found to correspond very accurately with the original fuel. It also has been found unnecessary to distill off more than twice the volume of the liquid in the flask *after a constant temperature has been reached*. Indeed, samples of the distillate collected but a few minutes after the equilibrium temperature had been attained agreed very closely in composition with that of the original fuel.

VAPOR-PRESSURE MEASUREMENT

Only one important modification has been made in the apparatus employed in the measurement of vapor-pressures. This consists in the employment of a specially constructed capillary vacuum stopcock, *d*, at the top of the vapor-pressure bulb; the bulb, as used at present, being shown at the right in Fig. 2. To make sure that this apparatus was giving reliable results, vapor-pressure determinations of several pure compounds were made; namely, benzol, water and absolute ethyl alcohol. These determinations were found to agree within 1.0 deg. cent. (1.8 deg. fahr.) with the data given in Landolt-Börnstein[4] and in Marks' and Davis' steam tables[5]. An additional check on the accuracy of the vapor-pressure measurements is afforded by the fact that the curves pass through the point of equilibrium temperature at a pres-

sure of 760 mm. (29.92 in.) of mercury.

A rather serious difficulty lies in the presence of comparatively large amounts of air dissolved in the liquid hydrocarbons. A rather novel method of correcting for this error has been devised by H. T. Tizard and A. G. Marshall. It is described in their recent report on the Measurement of Vapor-Pressures of Hydrocarbon Fuels[6]. However, their method is rather tedious in its manipulation, and the authors have found that, by cooling the vapor-pressure bulb to about 20 deg. below zero cent. (4 deg. below zero fahr.) by using ice and calcium chloride, and evacuating to a pressure of about 1 mm. (0.039 in.) of mercury with constant agitation of the apparatus, practically all of the dissolved air can be expelled from the liquid with an entirely negligible loss of the volatile constituents of the gasoline. The last traces are then swept out by allowing the temperature to rise until a very small amount of the liquid has been boiled off under low pressure.

The foregoing method gives results of sufficient accuracy for ordinary work. It is not to be recommended,

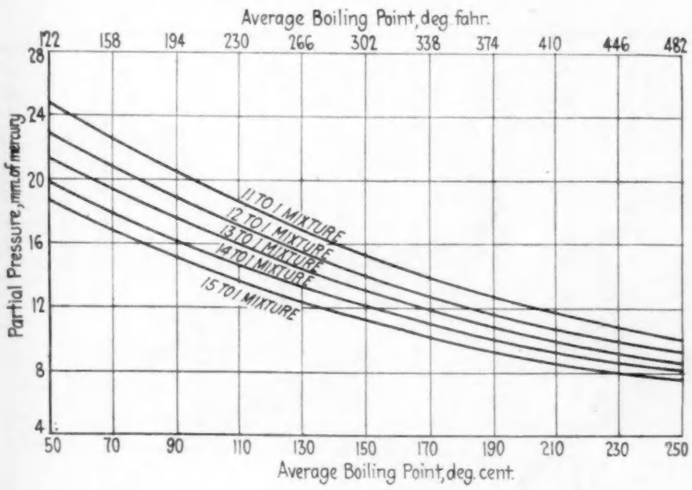

FIG. 4—CURVES SHOWING THE RELATION BETWEEN THE PARTIAL PRESSURES OF FUELS IN VARIOUS MIXTURES AND THE AVERAGE BOILING-POINTS

however, for work where the vapor-pressures are small, say below 10 mm. (0.394 in.) of mercury.

AVERAGE MOLECULAR-WEIGHT DETERMINATION

The method used by the authors in determining the approximate average molecular weights of the fuels for use in calculating partial pressures is explained fully in their previous article[7]. The accompanying curve, Fig. 3, is used for determining the molecular weights corresponding to the average boiling-points obtained from the differential distillation-curves. The authors hope to replace this by a direct determination of molecular weight, although the errors introduced by the above easy, though approximate, method do not affect the condensation temperature by more than 2.0 deg. cent. (3.6 deg. fahr.).

PARTIAL-PRESSURE CALCULATION

The partial pressures of the various fuels in mixtures with air were calculated after the following method for gasoline with an average molecular weight of 114 in a 12 to 1 mixture at a pressure of 1 atmosphere.

$$\text{Partial pressure} = 1/114 \div (1/114 + 12/29) \times 760 \text{ mm. } (29.92 \text{ in.}) = 15.9 \text{ mm. } (0.626 \text{ in.})$$

[6] See *Journal of the Institution of Petroleum Technologists*, vol. 8, No. 31, p. 217

[7] See THE JOURNAL, November, 1921, p. 313.

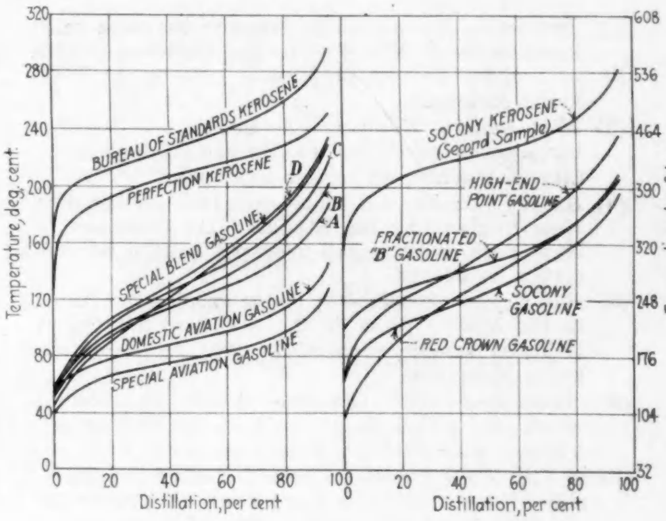

FIG. 5—DISTILLATION CURVES OF THE 14 FUELS TESTED

A chart has been constructed for convenience in use, shown in Fig. 4, in which the partial pressures of fuels in various mixtures have been plotted against their average boiling-points.

FUELS INVESTIGATED

As stated, the present paper embraces 14 fuels, including two of those covered by the original article. The results previously reported on the first fuel that was run, Socony kerosene, have been found erroneous, apparently due to failure to remove all the air from the flask or to leakage through the ordinary stopcock used at that time. The work on this fuel has accordingly been repeated, although, unfortunately, not enough of the original sample was at hand. The new sample that was procured, while corresponding closely, was not identical with the original fuel. The results on this second sample are recorded under the heading "Socony Kerosene, Second Sample." The distillation curves of the 14 fuels are given in Fig. 5, and the fuels themselves may be identified as follows:

(1) *Socony Kerosene*—A domestic kerosene marketed in New England by the Standard Oil Co. of New York; procured in a service-station in Boston

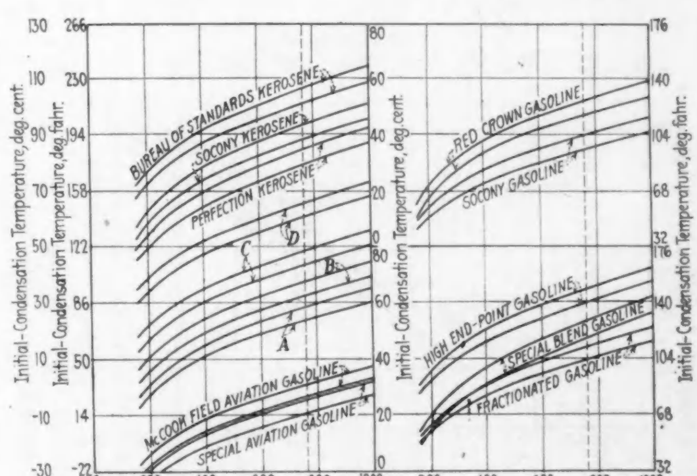

FIG. 6—CURVES SHOWING HOW THE INITIAL-CONDENSATION TEMPERATURES OF THE DIFFERENT FUELS VARY WITH CHANGES IN THE TOTAL PRESSURE

(2) *Perfection Kerosene*—A domestic kerosene marketed in the Middle West by the Standard Oil Co. of Indiana; sample supplied in 1921 by the Waukesha Motor Co.
(3) *High-Boiling Kerosene*—A sample of domestic kerosene procured at the Bureau of Standards, City of Washington; origin unknown
(4) *Socony Gasoline*—A motor gasoline marketed in New England by the Standard Oil Company of New York in 1921, and procured from a service-station in Boston
(5) *Red Crown Gasoline*—A motor gasoline marketed in the Middle West by the Standard Oil Co. of Indiana; sample supplied in 1921 by the Waukesha Motor Co.
(6) *"High-End-Point" Gasoline*—Socony gasoline to which was added 25 per cent of the first 50-per cent cut from distilling Socony kerosene
(7) to (10) *Four Fuels of Varying Volatility:*—Samples of fuels used for road tests carried on at the Bureau of Standards, City of Washington, under the cooperative fuel research program

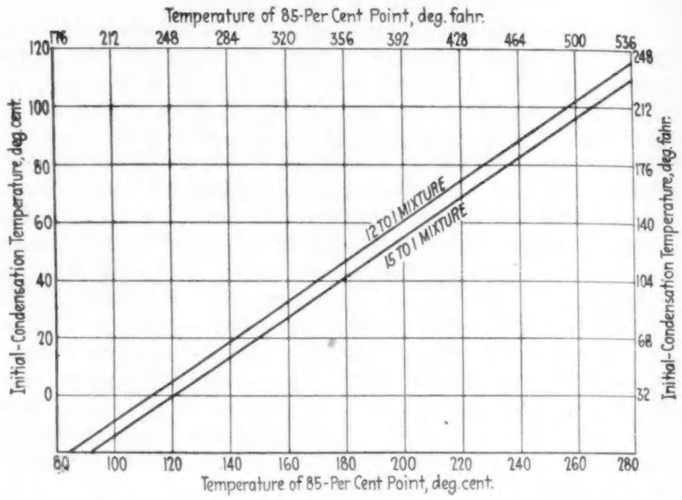

FIG. 9—VARIATION OF THE INITIAL-CONDENSATION TEMPERATURE WITH THAT OF THE 85-PER CENT POINT

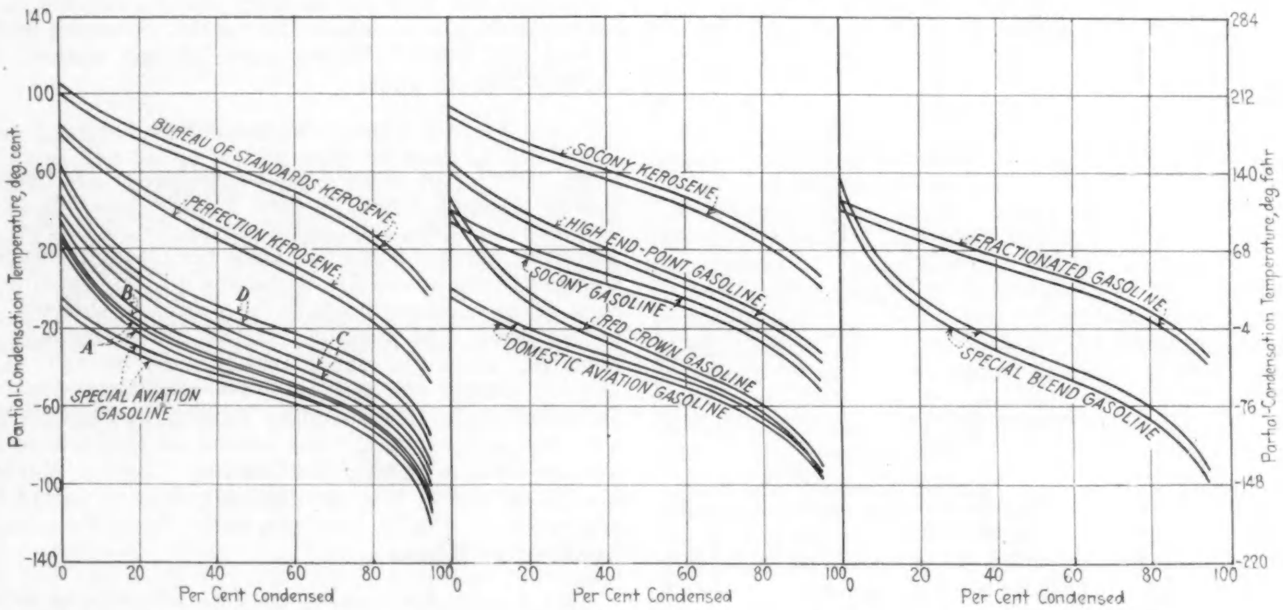

FIG. 7—CURVES GIVING THE APPROXIMATE PARTIAL-CONDENSATION TEMPERATURES OF THE DIFFERENT FUELS AT ATMOSPHERIC PRESSURE

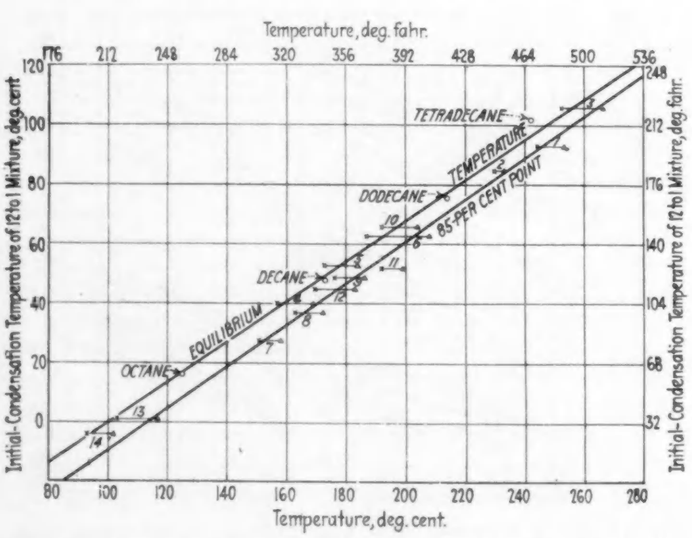

FIG. 8—RELATION OF THE DEW-POINTS OF MIXTURES OF VARIOUS FUELS TO THE EQUILIBRIUM TEMPERATURE AND THAT CORRESPONDING TO THE 85-PER CENT POINT

(11) *"Special-Blend" Gasoline*—An artificial blend prepared in the laboratory to have a wider distillation range, but the same average boiling-point, as fuel *C* in test No. 9
(12) *Fractionated Gasoline*—A product obtained by distilling fuel *B* in test No. 8 through a fraction-

TABLE 1—DEW-POINTS FOR A 12 TO 1 MIXTURE

Plotted Against Distillation Points, Per Cent	Average Deviation		Maximum Deviation	
	Deg. Cent.	Deg. Fahr.	Deg. Cent.	Deg. Fahr.
50	8.5	15.3	19.0	34.2
70	3.8	6.8	15.0	27.0
80	3.1	5.6	10.0	18.0
85	2.9	5.2	8.0	14.4
90	4.0	7.2	8.0	14.4
95	4.0	7.2	10.0	18.0
Dry Point	4.3	7.7	13.0	23.4
Equilibrium Temperature	3.0	5.4	10.0	18.0

TABLE 2—CHARACTERISTICS OF TYPICAL MOTOR FUELS[8]

No.	Kind of Fuel	Baumé Gravity Deg.	Specific Gravity	Distillation Data: Initial, Deg. Cent.	Initial, Deg. Fahr.	50 Per Cent, Deg. Cent.	50 Per Cent, Deg. Fahr.	80 Per Cent, Deg. Cent.	80 Per Cent, Deg. Fahr.	90 Per Cent, Deg. Cent.	90 Per Cent, Deg. Fahr.	95 Per Cent, Deg. Cent.	95 Per Cent, Deg. Fahr.	Distillation Range, Deg. Cent.	Distillation Range, Deg. Fahr.	Average Boiling-Point, Deg. Cent.	Average Boiling-Point, Deg. Fahr.	Average Molecular Weight	Molecular Heat of Vaporization from the Vapor-Pressure Curve, Cal. per Gram Mol.	Temperature of: 760 mm. (29.92 in.) of Mercury Vapor Pressure, Deg. Cent.	760 mm. Vapor Pressure, Deg. Fahr.	Equilibrium Solution at 760 mm. (29.92 in.) of Mercury, Deg. Cent.	Equilibrium Solution, Deg. Fahr.	Initial Condensation of a 12 to 1 Mixture, Deg. Cent.	12 to 1, Deg. Fahr.	Initial Condensation of a 15 to 1 Mixture, Deg. Cent.	15 to 1, Deg. Fahr.
1	Socony Kerosene, Second Sample	45	0.800	159.0	318.2	224.0	435.2	247.0	476.6	254.0	489.2	277.0	530.6	118.0	244.4	225.0	437.0	178	9,350	....	....	....	....	95.0	203.0	89.0	192.2
		....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	11,200	244.0	471.2	244.0	471.2	....	....	....	....
2	Perfection Kerosene	42	0.814	126.0	258.8	213.0	415.4	228.0	442.4	234.0	453.2	251.0	483.8	125.0	257.0	210.0	410.0	168	6,930	....	....	....	....	85.0	185.0	80.0	176.0
		....	....	134.0	273.2	230.0	446.0	246.0	474.8	249.0	480.2	270.0	518.0	76.0	168.8	228.0	442.4	180	10,700	227.0	440.6	230.0	446.0	....	....	....	....
3	No. 3 Kerosene	....	....	168.0	334.4	233.0	451.4	258.0	496.4	266.0	510.8	296.0	564.8	128.0	262.4	233.0	451.4	184	7,770	....	....	....	....	105.0	221.0	101.0	213.8
		....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	11,750	251.0	483.8	252.0	485.6	....	....	....	....
4	Socony Gasoline	60	0.743	60.0	140.0	128.0	262.4	160.0	320.0	169.0	336.2	196.0	384.8	136.0	276.8	128.0	262.4	115	7,510	....	....	....	....	40.0	104.0	34.0	93.2
		....	....	83.0	181.4	195.0	383.0	218.0	424.4	225.0	437.0	242.0	467.6	159.0	318.2	182.0	359.6	147	8,600	158.0	316.4	157.0	314.6	....	....	....	....
5	Red Crown Gasoline	57	0.752	35.0	95.0	138.0	280.4	177.0	350.6	184.0	363.2	210.0	410.0	185.0	365.0	131.0	267.8	117	6,500	....	....	....	....	53.0	127.4	48.0	118.4
		....	....	85.0	185.0	185.0	365.0	211.0	411.8	224.0	435.2	253.0	487.4	168.0	334.4	184.0	363.2	148	7,450	175.0	347.0	173.0	343.4	....	....	....	....
6	High End-Point Gasoline	57	0.752	62.0	143.6	154.0	309.2	150.0	302.0	208.0	406.4	236.0	456.8	174.0	345.2	147.0	296.6	126	7,550	....	....	....	....	63.0	145.4	58.0	136.4
		....	....	132.0	269.6	218.0	424.4	233.0	451.4	238.0	460.4	256.0	492.8	124.0	255.2	204.0	399.2	163	10,600	187.0	368.6	187.0	368.6	....	....	....	....
7	Cooperative Fuel Research Gasoline: Grade *A*	62	0.727	49.0	120.2	121.0	249.8	151.0	303.8	160.0	320.0	170.0	338.0	121.0	249.8	121.0	249.8	111	5,100	....	....	....	....	28.0	82.4	24.0	75.2
		....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	7,770	150.0	302.0	151.0	303.8	....	....	....	....
8	Cooperative Fuel Research Gasoline: Grade *B*	61	0.733	52.0	125.6	126.0	258.8	164.0	327.2	174.0	345.2	202.0	395.6	150.0	302.0	125.0	257.0	114	5,400	....	....	....	....	37.0	98.6	32.0	89.6
		....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	8,350	163.0	325.4	163.0	325.4	....	....	....	....
9	Cooperative Fuel Research Gasoline: Grade *C*	60	0.736	52.0	125.6	134.0	273.2	176.0	348.8	186.0	366.8	217.0	422.6	165.0	329.0	135.0	275.0	119	5,910	....	....	....	....	49.0	120.2	44.0	111.2
		....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	8,800	176.0	348.8	176.0	348.8	....	....	....	....
10	Cooperative Fuel Research Gasoline: Grade *D*	59	0.740	54.0	129.2	139.0	282.2	191.0	375.8	202.0	395.6	234.0	453.2	180.0	356.0	142.0	287.6	123	6,520	....	....	....	....	66.0	150.8	60.0	140.0
		....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	9,750	192.0	377.6	192.0	377.6	....	....	....	....
11	Special Blend Gasoline	59	0.740	45.0	113.0	134.0	273.2	188.0	370.4	199.0	390.2	231.0	447.8	186.0	366.8	135.0	275.0	119	5,780	....	....	....	....	52.0	125.6	48.0	118.4
		..	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	8,070	198.0	388.4	193.0	379.4	....	....	....	....
12	Fractionated Gasoline	....	....	36.0	96.8	146.0	294.8	168.0	334.4	182.0	359.6	208.0	406.4	112.0	233.6	147.0	296.6	127	7,830	....	....	....	....	45.0	113.0	40.0	104.0
		....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	8,900	170.0	338.0	170.0	338.0	....	....	....	....
13	Domestic Grade Aviation Gasoline	....	....	53.0	127.4	93.0	199.4	111.0	231.8	116.0	240.8	133.0	271.4	80.0	176.0	94.0	201.2	97	6,280	....	....	....	....	1.0	33.8	−4.0	24.8
		....	....	72.0	161.6	118.0	244.4	137.0	278.6	142.0	287.6	169.0	336.2	....	....	....	....	....	7,630	101.0	213.8	103.0	217.4	....	....	....	....
14	High-Volatility Aviation Gasoline	....	....	39.0	102.2	79.0	174.2	96.0	204.8	102.0	215.6	132.0	269.6	93.0	199.4	78.0	172.4	89	6,100	....	....	....	....	−4.0	24.8	−9.0	15.8
		....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	7,160	93.0	199.4	93.0	199.4	....	....	....	....

[8]The second line of data for each fuel applies to the equilibrium solution of that fuel.

ating column, and retaining that portion coming over between 100 and 200 deg. cent. (212 and 392 deg. fahr.)

(13) *Domestic-Grade Aviation-Gasoline*—A sample obtained early in 1922 from McCook Field, Dayton, Ohio

(14) *High-Volatility Aviation-Gasoline*—A sample of a special aviation gasoline obtained at the Bureau of Standards, City of Washington

Results of Experiments

The results of the tests on the above fuels are presented in graphic and tabular form and are, for the most part, self-explanatory. Fig. 6 shows the variation of the initial-condensation temperatures of the various fuels with different total pressures. Two curves are shown for each fuel, the upper one representing a 12 to 1 mixture and the lower one a 15 to 1 mixture. Similarly, Fig. 7 gives the approximate temperatures of partial condensation for the different fuels at atmospheric pres- the true condensation-temperature for paraffin hydrosure. As in the preceding case, the upper line represents the 12 to 1 mixture.

It was pointed out in the previous paper[9] by the authors that, for the three fuels tested, the average boiling-point of the equilibrium solution approximated that of the 85-per cent point of the original fuel. It also appeared that by subtracting 135 deg. cent. (275 deg. fahr.) from the 85-per cent point, it would be possible to *approximate* carbon fuels. While such a rule could not be expected to hold with great precision for fuels of widely different boiling-point or width of cut, its convenience for many practical purposes was so great that one of the main objects of the work on the 14 fuels was to determine whether any such generalization could be drawn for a wider variety of motor-fuels. With this end in view, the dew-points of the various fuels were plotted against several points taken from the distillation curves, namely, the 50, 70, 80, 85, 90 and 95-per cent and dry points, and also against the equilibrium temperatures observed in preparing the equilibrium solution. The results are shown in Table 1.

It was found that, in general, the relationship between the dew-points of the various fuels and any of the above points on their distillation curves could be approximated roughly by a representative straight line, but that the average deviation of individual observations was very large in the case of the 50-per cent or end-points, while plotting against the 85-per cent points gave the most concordant results, the average deviation being only 2.9 deg. cent. (5.2 deg. fahr.). In Table 1 are given the average and the maximum temperature deviations when the dew-points are plotted against the various distillation temperatures. In Fig. 8 are shown the initial-condensation temperatures for 12 to 1 mixtures plotted against the 85-per cent points and the equilibrium temperatures in degrees centigrade. The horizontal lines joining pairs of points indicate the differences in temperature between the 85-per cent points and the equilibrium temperatures. Four points are also added to represent the calculated dew-points of four pure paraffin hydrocarbons, and the approximate agreement of even these "perfectly fractionated" fuels indicates the fundamental validity of the relationship found for the various commercial fuels.

It will also be noted that, while the rule of subtracting 135 deg. cent. (275 deg. fahr.) from the 85-per cent point is approximately correct for the average motor-fuel, it varies consistently between 160 deg. cent. (320 deg. fahr.) for high-boiling kerosenes to 110 deg. cent. (239 deg. fahr.) for very volatile aviation-gasoline. The simplest method of determining the correct value is, however, to determine the 85-cent point of the fuel and then refer to Fig. 9.

Rather surprisingly, the accuracy with which the dew-point may be determined from the 85-per cent point of the ordinary distillation curve, appears to be fully as good as when it is found by determining the equilibrium boiling point by the recommended method. In other words, it is apparently not worth while to prepare the equilibrium solution unless it is to be used for accurate vapor-pressure measurements as described by the authors. The determination of the equilibrium boiling point is, however, a simple matter, and the value for the dew-point found by referring to the upper line in Fig. 8 is a valuable check on that determined from the 85-per cent point by referring to the lower line in the same illustration. The average of the two should be correct within 2 or 3 deg. cent. (3.6 or 5.4 deg. fahr.).

One important corollary of the relationship between the 85-per cent point and the dew-point is that, in increasing the yield of motor-fuel by a closer fractionation of the crude, if a fractionated fuel is to have the *same effective volatility* as another fuel made by sample distillation, it should be made to have *the same 85-per cent point*, and hence *a lower end-point*, rather than trying to crowd in everything possible below the same end-point. This fact is, of course, tacitly recognized by the increasing emphasis on the 90-per cent point in motor-fuel specifications. This is practically as good as an 85-per cent point specification, and certainly far better than the over-emphasized end-point.

The results of all the experimental work to date have been summarized in Table 2.

[9] See The Journal, November, 1921, p. 313.

ADDRESSES OF MEMBERS WANTED

A FORCE is maintained in the offices of the Society at New York City whose sole duty is to keep the addresses of the members uptodate. A large number of changes of addresses are received each week by this department, and these are made promptly. In numerous cases the only notification which the Society has of a change of a member's address is a letter stating that The Journal, or some other communication, either was delayed in delivery or was not received at all. It is, of course, impossible for the office to have a correct list of addresses unless the members send in such changes promptly.

A list of the members for whom the Society has no correct address is given below. Communications sent to the last known business connection or mail address as it appears on the records have been returned to the New York office. Any one who can supply information regarding the present location of these members or offer any suggestions as to where their correct addresses can be obtained will confer a favor upon the Society by communicating with the Secretary at the New York office. It is only by the cooperation of the membership that a correct mailing list can be maintained and the members receive The Journal and other communications promptly.

Boggs, George. A.
Bruenauer, Otto
De Lorenzi, Ernest Adolph
Hewitt, Clarence C.
Magoffin, Charles F.
Miller, Lesterb
Morton, R. B.
Smith, George W.
Ver Linden, Edward
Willard, Charles F.
Wissel, Ernest J.

Special Notice

TRANSACTIONS, PART II OF VOL. 16 (1921).

To Those Who Paid Dues for the Last Half of the Fiscal Year Beginning Oct. 1, 1920:

Part II of Vol. 16 (1921) and the two Parts of Vol. 17 (1922) will be sent, without charge in addition to payment of respective dues, to members on request, if request is received by the Society within 60 days from date of notice to order.

This is a notice to order Part II of 1921 Transactions.

The printing order will be based on the number of copies ordered by the members.

Copies cannot be guaranteed to members who do not order them on or before May 10, 1923

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SOCIETY OF AUTOMOTIVE ENGINEERS, INC.
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Date S.A.E. Member

Research Foundation for the Economic Theory of Highway Improvement

By W. K. HATT[1]

AT the meeting of the Society of Automotive Engineers at West Baden, Ind., a joint committee of automotive and highway engineers was authorized to study the mutual relations of the vehicle and the road. Since that time the need for scientifically determined data has been growing, not only as a basis for mechanical relations, but as a guide to wise legislation.

Men seem unanimously in favor of research in general, and any proposal for attack upon the outstanding problems through research methods is received with approval. However, to organize the proposed research, to secure the resources for its prosecution and to find available men for the actual operations is not so easy.

But lying back of even these preliminaries is a common understanding of the objectives of such research and a mutually agreed upon allocation of the fields of operation. There is an inertia to human mentality, and such common understanding and purpose apparently requires growth in time. Happily, the automotive and the highway engineers have joined together for the purpose of fruitful research. At a meeting in New York City not long ago, attended by representatives of the automotive engineers, the highway engineers, and the motor-vehicle builders, an understanding was reached on the following outline of necessary research which was designated as a program upon which efforts would be concentrated. Activities in this program are not academic, but vital to the treatment of grave questions now pressing upon the public mind.

RESEARCH FOR THE AUTOMOTIVE ENGINEER

By laboratory tests to determine

(1) Fuel, oil and grease consumption and power development of the vehicle, and from these to calculate the performance on various surfaces and grades and the excess power for moving trailers. (See Bulletin of Michigan State Highway Department on Experiments by Prof. W. E. Lay.)

(2) To study the effect of improved grades on the design of the powerplant of the vehicle

(3) To consider the design of the vehicle to impose on the road the minimum loads for specified capacities of vehicle

(4) To study the lighting system of automobiles with a view to safety and the mechanisms indicating intentions of the driver

RESEARCH FOR THE HIGHWAY ENGINEERS

(1) To find rolling and air resistance of motor vehicles at various loadings and speeds on types of road surfaces and curves; limit of adhesion

(2) To determine the loads imposed on road surfaces by various vehicles, with various tire equipment at various speeds

(3) To discover the stresses and strains acting in various road surfacings under the expected loads and the properties and improvements of subsoils

(4) To determine the capital and maintenance costs resident in the road

(5) To determine the laws governing the increase of highway traffic by basic surveys of flow of traffic in typical regions

RESEARCH FOR NATIONAL AUTOMOTIVE CHAMBER OF COMMERCE AND AUTOMOBILE ASSOCIATIONS

(1) To assign schedule cards to a selected group of, say, 200 passenger drivers for each condition, to obtain operating expenses on the average for
- (a) Three classes of car
- (b) Regional conditions
  - Macadam and gravel roads
  - Dirt roads
  - Paved roads
- (c) Topography
  - Level
  - Hilly

(2) To study records of truck and passenger bus fleets to obtain similar data

LOCATING HIGHWAY ENGINEER

Given the road resistance, the power available at the wheels, the speeds, the fuel, oil and grease consumption, the tires, the repairs, the driver's time, the depreciation, the overhead, and the expected traffic

To find the relation between the capital costs of the construction and operating expenses on roads of various surfaces and grades, length and rate

FEDERAL AGENCIES

(1) To study the movements of commodities and passengers by the highway and the railroads in the interest of coordination of transport

(2) To study the financing of highway improvements in the light of experience and science in related fields of the financing of public improvements

(3) To study the effect of highway improvemets on regional industries

(4) To study the effect of highway improvements upon the general productivity of men and industries

ADVISORY BOARD ON HIGHWAY RESEARCH

To evaluate the progress in the several fields of highway research by an analysis of completed and current projects; to outline needed researches; to assist existing organizations to correlate their work in the light of a comprehensive program; and to publish bulletins of information on methods and technique of research, and on progress in the several fields

It will be noticed that in this program the usual experiments on road resistance have been definitely divided as between the automotive and the highway engineer. This proposal is the result of a gathering held at the National Research Council in the City of Washington on July 14, 1922, at which the following report was adopted:

TRACTIVE RESISTANCE OF MOTOR VEHICLES

Rolling-Resistance is the resistance to translation arising from the interaction of the road and the vehicle, but excluding the resistances in the engine and transmission system.

[1] Director of the advisory board on highway research, National Research Council, City of Washington.

Explanatory Note. — As ordinarily measured, this includes wheel-bearing resistance, which in the case of well-conditioned cars should not exceed 5 lb. per ton. Rolling-resistance by the definition also includes the resistance in the framework and spring-suspension system of the vehicle arising from the road. Rolling-resistance as measured contains various degrees of impact and road displacement effects depending upon the condition of the road and the design of the vehicle. The resistance due to the horizontal curvature of the road should be measured in the experiments.

Note.—It is the purpose of the tests of rolling-resistance to determine the force at the rear axle or the tire periphery necessary to move the vehicle, as conditioned by the road surface, the type of road, the tire equipment, the class and the weight of the vehicle, etc.

Air-Resistance is the resistance arising from the relative velocity of the air and the vehicle.

Explanation.—Ordinarily this resistance is included in the tested resistance, and should be subtracted to obtain the rolling-resistance. Investigations are needed to determine the law and the coefficient of this resistance for various vehicles.

Rolling and air-resistances are those resistances determined when a vehicle is towed with the power transmission mechanism disconnected from the driving-wheels. However, the difference between a self-operated and a towed vehicle in respect to tire losses and slipping may make some difference in results, especially at high speeds.

Note.—Having the rolling and the air-resistance, it becomes the function of the automotive engineer to design an efficient vehicle to furnish power for economical transportation over various alignments.

Transmission-System Resistance is the force required at the rear axle or the tire periphery to overcome all internal resistance from the clutch to the rear axle.

The transmission-system resistance depends upon the gear-ratio in mesh and the power transmitted, as well as upon other conditions, such as the speed, the temperature of the lubricant, etc. These losses are best determined in the laboratory.

Engine Resistance is the force required at the rear axle or the tire periphery to overcome the resistance of the engine, including the cooling system, fan and accessories.

Engine resistance depends upon the operation of the engine as regards the throttle opening, the speed, the temperature and the mechanical condition of the engine. These resistances are best determined in the laboratory.

Equipment and Instruments.—Rolling and air-resistance should be measured for basic types of motor vehicle and of tractor. For purposes of comparison of the economy of types of road, expressed in fuel-consumption, the time of translation and other costs of maintenance of the vehicle and the road, the rolling-resistance should be measured to an accuracy within 5 per cent.

The present state of the art indicates that at low speeds up to 10 m. p. h. a traction dynamometer of the liquid-pressure type, or a space-time recorder, is considered best fitted. At higher speeds, a space-time recorder, or a U-tube accelerometer, is most satisfactory. New instruments should be investigated, especially the torsion dynamometer.

Tests should be made of the adhesion of the tires to the road surfaces under running conditions to determine safety against skidding under various conditions of brake and tire equipment and road. The use of an accelerometer with locking of brakes is recommended.

Relation of the Automotive to the Highway Engineer

The automotive engineer needs data on the rolling and air-resistances rather than data on the gasoline consumption from road tests, since the latter depend upon the individual characteristics of the vehicle used, the carbureter, the habits of the driver, etc. Having the power factors, the automotive engineer will design the plant to furnish the power required.

From the standpoint of the highway engineer, a problem like the following is set:

> A reduction in the grade of 4 ft. will reduce the amount of energy required by 8,000 ft-lb. What will this be worth in the saving of gasoline and the other operating expense for the traffic considered? Will the solution be for cars as at present built, or for cars using the roads 15 years from now? The mutual relation of the highway and the vehicle is expressed in the effect of low grades on changes in the engine design and the power requirements of the car. Inasmuch as the large expense of highway transportation is in the expense of operation of transportation rather than in the fixed charges and the maintenance of the road, the investigation of the costs of operation of traffic is particularly needed.

The fuel cost and time required, as affected by the type and the design of the surfaces and the grades, are measurable by experimental methods, and the depreciation of the vehicle and the other maintenance costs should be evaluated from a study of the statistics of motor vehicles obtained in actual operation.

In other words, it is considered practicable to determine the road performance of the vehicle from tests made in the laboratory combined with data on the rolling and the air-resistance. It appears that the available data from the several investigations of rolling-resistance will define the limits of this resistance for the various classes of road with a sufficient degree of accuracy for the purpose in view.

The subjects listed in (2) and (3) under the heading Research for the Automotive Engineer will no doubt suggest that there will be opportunity for productive research in these fields for some time to come. A study of the lighting systems of automobiles, mentioned in (4), cannot be delayed if current legislation is to be based upon physics rather than on ideas.

The highway engineers have planned to carry out item (2) in their section of the program in the early summer months. It is the opinion of some that data on item (3) have accumulated to such an extent that the services of the analyst are needed more than further experiments of large magnitude. Data of maintenance costs, item (4), are largely wanting. With reference to (5) the laws governing the increase of highway traffic should be known for a wise planning of road development. The only study of outstanding quality and quantity is that by Dean A. N. Johnson, of the University of Maryland, covering the development of traffic in Maryland.

I understand that the American Automobile Association is cooperating with the committee on the economic theory of highway improvement of the National Research Council in an endeavor to obtain average values of the operating expense of passenger cars.

The remaining sections of the program of research contain titles that define general research of a more difficult character, but the outcome of which would be basic in highway development.

Military-Airplane Development and Construction in Peacetime

By F. H. Russell[1]

Annual Meeting Paper

THE reconstruction period since the war has served to establish aviation as an essential arm of both the military and the naval forces of the Government. This in itself is a real accomplishment. But for several reasons the airplane industry has not performed the service that was expected of it and has not received the support that is necessary for its existence. Although the expense is great, the development of aviation through the facilities at McCook Field and at the Naval Aircraft Factory has been hampered by red-tape and by the fact that the personnel of the Government agencies are at the same time the judges of new developments and the competitors of the engineers in the industry. The result is a feeling of reticence among civilian engineers with regard to disclosing and developing new ideas, the retarding of the advancement of service types, and slow deliveries. Although several companies at the close of the war were well equipped to produce airplanes cheaply and efficiently, these gradually have been driven out of existence and their places have been taken by smaller organizations that depend solely on casual orders which return small profits.

Competitive bidding has resulted in delay to the Government and loss to the manufacturer; in some instances bids have been asked on machines that had not been sufficiently developed to allow the Government to furnish blueprints, design data or a bill of material. The safety of the Nation is predicated on a dependable source of supply of equipment, especially aircraft. An important function of the Government, therefore, is to see that the engineering and production data are complete, uptodate and practical. This is not usually the case, the contractor being depended upon to complete and correct the data; and an unforeseen loss of time and money has been entailed. Early development of the art of aviation was due to the genius of a few men, but the development of the future will be by organization, with specialists in every line; the production of the world's fastest airplane at the races in Detroit is a case in point. Confusion has arisen through the custom of ordering new types in small quantities and of depending on competitive bidding for the further supply, on the assumption that when once completed the article was "commercial" and not proprietary.

The suggestion is made that the experimental work and the subsequent developments be confined to the same organization, with provision for production in large quantities in time of war. The Government's problem should be the selecting of airplanes for training and operating, and the guiding of the industry in developing such designs. Engineering and production should go hand-in-hand. Government subsidies, such as are customary in other countries, are not needed yet but production must be encouraged through the supply of Government equipment. Particular types of airplane should be considered proprietary, but the Government should be free to purchase any design at any time in any stage of advancement and place it by competition or assignment with recognized units in the industry.

Cross-licensing, originated as a war concession by patent owners, has had the effect of causing some persons to feel that any airplane should be purchased by open competitive bidding. But this agreement did not contemplate encouraging one manufacturer to use another's design or standardizing construction so that it could be used by all. Competitive bidding should be used only when a producer has been found incompetent or unwilling to furnish his product at a reasonable price under reasonable conditions. Considering each type of airplane as proprietary would make for permanence of business, encourage small companies to increase their facilities and guarantee to the Government a source of supply in time of peace and the distribution of data and personnel in time of national need.

It may seem somewhat trite to suggest that in time of peace we should prepare for war. The possibility remains, however, that amid the pressing detail of individual problems we may lose sight of the necessity for maintaining a healthy aeronautic industry. A review, therefore, of the situation, as it appears at the beginning of 1923, may prove of value and awake an interest among those intimately connected with this problem so that our usefulness shall be increased.

During the four years that have elapsed since the war, aviation has established itself as an essential arm of both our military and naval forces. The experiments and operations carried on by the Air Service of the Army and the Bureau of Aeronautics of the Navy Department are entirely responsible for the important place that aircraft occupies in the military plans of our General Staff and the General Board. This in itself is a very real accomplishment.

It is felt, however, that during this constructive period the airplane industry has not performed the service that was to be expected of it; nor has it received the support essential to its very existence. Considerable effort has been expended by both services in endeavoring to establish a system by which new types of aircraft might be developed and a method by which their supply for current requirements might be secured. Government purchases must be made in accordance with the provisions of the appropriation acts, together with existing regulations, but these, although satisfactory for the procurement of commercial articles, do not lend themselves easily to the engineering problems of new development and small production.

The Air Service has attempted to solve the problem of development through the maintenance and the increase of facilities in its engineering division at McCook Field, and the Bureau of Aeronautics for the Navy has maintained the Naval Aircraft Factory at Philadelphia, not only for repairing existing equipment, but for constructing small quantities of experimental types. The cost of maintaining these two organizations has well-nigh exceeded the entire expenditure for aeronautical equipment in the aircraft industry since the war.

The actual development and construction of aircraft by these agencies places the Government in a position in which its personnel not only are the judges and experts

[1] Vice-President, Curtiss Aeroplane & Motor Corporation, Buffalo.

of new development, but are themselves competitors of the engineers in the industry. While the individual officers have, it is believed, cooperated with the industrial units to the best of their ability, the fact, nevertheless, remains that among civilian engineers a feeling of reticence exists in the matter of disclosing and developing new ideas, which discourages the free intercourse that should exist between the user and the designer.

Old Designs and Slow Delivery

The development of new types by the industry, under the present restrictions, which have seemed necessary when dealing with many of the factories not properly manned and equipped, has been unreasonably slow and has retarded the advancement of service types in both the Army and the Navy. The Army is now receiving deliveries of a pursuit airplane for service use that was exhibited originally in the Aeronautical Show in 1919!

Investigation indicates that, of 117 ships delivered to the Navy during the fiscal year ended June 30, 1922, 52 emanated from the Government factory at Philadelphia, 17 from foreign sources and but 37 from the entire American aircraft industry.

A review of the designing and manufacturing units in the industry at this time will disclose even more clearly the seriousness of this situation. At the close of the war several well-organized companies were producing airplanes cheaply and efficiently. It would be supposed that with the reduced requirements of the Government we might have relied on the principle of the survival of the fittest to maintain and support the organizations best equipped to carry on the supplying of aircraft material. This, however, has not been the case. Among the larger companies the results of operating have been expressed from year to year by red figures in their balance sheets, and have driven and are today driving out of the business well-established, well-manned and well-financed factories, leaving in their places an increasing number of smaller units devoted particularly to developing whatever engineering order may be secured from time to time, with little regard to the permanency of their existence. The small engineering development orders given by the Government to such organizations generally have produced small profits. The further production, however, under competitive bidding by the larger units, of the machines thus developed, has resulted in delays to the Government and in serious losses in almost every case to the manufacturer. So-called production orders for from 25 to 50 machines have been offered to the industry from time to time by the Government for competitive bidding, when the machine itself was not sufficiently developed even to allow the Government to furnish blueprints, design data and bills of material that it could guarantee as correct. In a recent competition complete production drawings did not exist and there was no physical sample of the airplane available for the prospective bidders to study in making their estimates. Competitive bidding on airplane contracts has degenerated into a reckless gamble among desperate producers, who are willing to take any chance to obtain a contract and keep operating, and rely either on the mercy of the Government or on the appearance of an enthusiast in the rôle of a fairy godmother to meet the financial loss when it arrives. This explains why, in the instance above referred to, the bids of about a dozen producers ranged from less than $500,000 to nearly $1,250,000. This is not competition; it is nothing but industrial suicide. A continuance of this way of distributing business will destroy the industry.

The plans of our military forces on which the safety of the Nation depends in time of war must be predicated on a dependable source of supply of the equipment to be used. This is especially true in the matter of aircraft, which at present has no market worth considering except that of supplying the Government. It devolves, therefore, upon the Government to see that every dollar spent for construction is used to maintain the industry and render it capable of expanding.

There was a period in the development of the art when its advance was due directly to the individual genius of various men whose names may well be recorded as pioneers. It is believed that their work has been largely accomplished, and that the future development of the flying machine, for military or commercial purposes, will be brought about through the unceasing efforts of groups of engineers, each a specialist in his line, cooperating in one commercial organization for the production of the type desired. The results of the 1922 speed races at Detroit are an example. In this competition an opportunity was given to design and construct machines of various types under both methods of development. The world's fastest airplane was not the product of a single genius, but rather the result of the properly directed efforts of assistant engineers, each of whom was an expert in some branch, such as aerodynamics, power, radiation and strength of materials. In the design and construction of this airplane the Air Service made an exception to its general custom of requiring submission and approval of each individual detail, and insisted only that the strength factors be maintained and that the guaranteed speed be delivered in a practical airworthy machine. The result was that the engineers, having a free hand and a real responsibility, rose to the task, and the machines were designed and built in 90 days, whereas under ordinary service regulations more than a year would have been required to complete them.

Through the effort to maintain the industry there has arisen a confusion of ideas with reference to the creation of a type and the production of it in small quantities under so-called production contracts. The custom of ordering new types from a creative organization in quantities of one, two or three, or even ten or twenty, and then depending upon open competitive bidding for further supply on the assumption that the engineering problem had been completed and that the article was "commercial" and not proprietary, has failed to furnish the Government with airplanes promptly and to sustain the manufacturer.

It is believed that the design of a new type and its subsequent development should be placed with one organization, which, having created the experimental article, should be expected to supply it in such quantities as might be required for peacetime operation. The necessity for reproducing it in large quantities for war use must be considered as important a factor in the design as is the actual aerodynamical efficiency of the machine itself. This requirement has not received the attention it deserves by either the Government or the civilian engineer.

The Government's Peacetime Problem

The peacetime problem of the Government engineer clearly is, first, the selection of the types of airplane that are required for actual military training and operations; and, secondly, the guidance and support of the industry toward the developing of such designs, having in mind constantly that the airplane developed must not only be satisfactory for the service desired, but be designed in detail so that it will be capable of quantity reproduction.

Both the Air Services and the units in the industry

should thoroughly appreciate that, to be effective in service, civilian aircraft organizations must consist not only of a capable group of creative engineers, but also of men trained and experienced in production manufacturing; that the physical facilities should include not only wind-tunnels and aerodynamic, physical and chemical laboratories, but also the latest types of production machinery; and, further, that such an organization should have sufficient financial resources to sustain it when operating as a complete unit. Any separation of engineering from production, such as is found in the types of airplane developed by small engineering units, or of production from inadequate creative engineering, is bound to result disastrously. The two must go together, and the Government must establish a policy which, under proprietary orders, a company may specialize in the development of one design or class of machine, build it continually in small quantities and constantly improve it. Such an organization should be required at the same time to supply standardized blueprints, specifications, bills of material, and the like, which, in time of national emergency, could be placed at once in the hands of constructors outside the industry for quantity production.

It should not be inferred from these suggestions that the business of supplying the United States Government with aeronautical material should be centralized among any favored few. This, of course, would not only be contrary to our way of doing things, but certainly would retard growth. On the other hand, it is believed that the aircraft facilities of the Country should be surveyed very carefully by the purchasing branches of the Air Services, with the idea of ascertaining both what units and how many they can support with the funds and projects available, and then encourage the units that most nearly meet the requirements.

It must be realized that European countries are approaching this problem from another point of view. England, France and many other countries are subsidizing commercial aeronautics, and thus are encouraging production, while in this country we have not yet been able to get the Congress even to give us a law to regulate air navigation. We do not need subsidies yet, but we must sustain healthy production units through the supply of Government equipment.

An airplane of a particular type should be considered a proprietary article. No one, either within the Government or without, would consider an automobile of any one type, such as the Pierce-Arrow, for example, so commercial as to be procured by competitive bidding on the open market. Aeronautical engines are not so considered by the Government. To protect itself, the policy of the Government is to develop two or more types of engine for each service required. The same policy should prevail in the supply of airplanes. The suggestion often has been made that the allocation of work under types that an organization is particularly qualified to supply would prevent the Government from using to advantage the genius of individual inventors and engineers. This is not the case. The Government should be free to purchase at any time a design, in whatever stage of completion it finds to be advantageous, from anybody, and then to place it through competition or by assignment with the recognized units in the industry. It should not expect to obtain a practical production airplane from an individual or from a small organization, but should use its efforts at all times to bring individual engineering ability into existing civilian organizations, and not encourage the formation of new companies whenever a new design is to be considered.

Cross-Licensing

One reason that many persons have come to feel that any company could build any airplane, and that the Government should purchase airplanes only through open competitive bidding, as it would any other commercial article, is the fact that all of the principal aircraft patents are cross-licensed under the Manufacturers Aircraft Association, for membership in which any aircraft contractor to the Government is eligible. This cross-licensing agreement, originally a war concession by the patent owners to the Country, in order that the Government might not be restricted in any manner in developing its sources of supply, has been of the greatest value to the industry in opening practically to all the opportunity to use any patented improvement.

This agreement, however, did not contemplate the encouraging of one manufacturer to build from another's specific design, or suggest that the construction of aircraft was so standardized as to make any design capable of reproduction by all. Non-exclusive patent rights are granted to all members, but design rights are subject to individual negotiation.

Competitive bidding on design should be used by the Government only in cases where the producer has been found incompetent to supply or unwilling to furnish his product at a reasonable price under reasonable conditions. Each type of aircraft must be considered as proprietary. Such a policy would make for permanence of business and encourage individual companies to increase, or at least to sustain, their present facilities; guarantee to the Government a source of supply in time of peace, and assure the practical distribution of both manufacturing data and skilled personnel among other industries requisitioned to aircraft production in time of need.

For four years the industry has cooperated with the Government agencies in every possible way, endeavoring itself to survive at the same time. The point has now been reached where we can see clearly the destructive elements in the present Governmental policy, and it is the duty of the Government to amend its system so that the aircraft industry may be ready at any and all times to meet a national emergency. It is hoped that the public never again will be able to accuse us of unpreparedness, inefficiency or incompetency.

A New Interpretation of Exhaust-Gas Analysis

By E. H. Lockwood[1]

GASES of combustion may be analyzed conveniently by the standard Orsat apparatus. Its uses are limited, however, to cases where the combustion is nearly complete, leaving no unburned fuel except small amounts of carbon monoxide. Fortunately this condition generally is complied with where solid and liquid fuels are used, as in boiler furnaces and internal-combustion engines. In the testing of such powerplants, the Orsat apparatus may contribute results of much value as regards the efficiency of combustion.

It will be unnecessary at this time to describe the Orsat apparatus, but reference may be made to its general method of operation. The first step in the analysis is to draw exactly 100 cubic units of the gas into a cylindrical glass tube, where volumes can be measured by a scale etched on the glass. The gas sample is then passed successively into three chambers, where it comes into contact with chemicals that absorb the different components of the gas. After each absorption the sample is returned to the graduated cylinder, where the loss of volume is read in percentage on the scale. The components found in this way are carbon dioxide (CO_2), oxygen (O_2) and carbon monoxide (CO). Finally, their sum is subtracted from 100 and the remainder is assumed to be nitrogen (N_2). A complete flue-gas analysis consists of the four items just mentioned, the sum of which is always 100. The carbon monoxide item is usually small and may be zero. The nitrogen item is always large, say, 80 per cent of the total.

After the completion of the analysis the results must be interpreted. This usually is done by elementary chemical arithmetic, based on the combining formulas for carbon dioxide and monoxide, the atomic weights of the elements, and the proportions of oxygen and nitrogen in the air. The arithmetical method determines the weight of air used in the combustion of the carbon, but fails to reveal the amount used by the hydrogen in the fuel. The latter must be determined by a supplementary computation based on the amount of hydrogen in the fuel.

The arithmetical computations are fairly simple, but the constants are easily forgotten unless used frequently. To avoid the drawbacks of the chemical theory, algebraic formulas have been devised for producing the same results by simple substitution of the gas-analysis percentages and for solving the equation. The following formulas have been widely used for this purpose:

$$\text{Air per pound of carbon} = 3.03\, N_2 \div (CO_2 + CO) \quad (1)$$

$$\text{Dry gas per pound of carbon} = \{ 11\, CO_2 + 8\, O_2 + 7\, (N_2 + CO) \} / 3\, (CO_2 + CO) \quad (2)$$

$$\text{Ratio of the air actually used to the air theoretically required} = N_2 / \{ N_2 - 3.78 (O_2 - CO/2) \} \quad (3)$$

Formula (1) is usually credited to Dr. D. S. Jacobus and (2) to R. S. Hale. All are deduced in Gebhardt's Steam Power Plant Engineering. They are examples of ingenious reasoning, because they take into account the air required by the hydrogen in the fuel as well as by the carbon. The drawback lies in basing the various quantities on the carbon in the fuel, whereas it is much more convenient to use the combustible in the fuel. The reason is that the combustible is given by the simple proximate analysis, which is the sum of the fixed carbon and the volatile matter, while the carbon is given by the ultimate analysis, which is relatively costly and rarely available.

A modification of the formulas, based on combustible, can be easily made. Furthermore, by a logical extension of the reasoning, formulas can be derived for the proportions of carbon and hydrogen in the fuel, for the water vapor formed by combustion, and for the theoretic air required for the combustion of the fuel. I offer my formulas for the consideration of those interested. Before stating the new formulas, it will be in order to mention certain limitations that apply alike to the old and to the new formulas. First, the formulas apply only to fuels that contain negligible amounts of nitrogen. Fortunately this includes the ordinary forms of coal and liquid fuels. Secondly, the sulphur in the fuel is also assumed to be negligible in amount. Thirdly, the term hydrogen refers to the so-called free hydrogen, $H - (O/8)$, or the portion of the hydrogen that requires air for its combustion. The derivation of the formulas, which are given below, will be omitted here and placed in an appendix, as the explanation is rather technical.

Air per pound of combustible =

$$\frac{18.3\, N_2}{0.525\, N_2 + 5\, CO + 4\, CO_2 - 2\, O_2} \quad (4)$$

Dry gas per pound of combustible =

$$\frac{22\, CO_2 + 16\, O_2 + 14\, (N_2 + CO)}{0.525\, N_2 + 5\, CO + 4\, CO_2 - 2\, O_2} \quad (5)$$

Theoretical amount of air per pound of combustible =

$$\frac{18.3\, N_2 + 34.8\, CO - 69.6\, O_2}{0.525\, N_2 + 5\, CO + 4\, CO_2 - 2\, O_2} \quad (6)$$

Percentage of excess air =

$$\left[\frac{69.6\, O_2 - 34.8\, CO}{18.3\, N_2 + 34.8\, CO - 69.6\, O_2} \right] \times 100 \quad (7)$$

Water vapor per pound of combustible =

$$\frac{4.77\, N_2 - 9\, CO - 18\, (CO_2 + O_2)}{0.525\, N_2 + 5\, CO + 4\, CO_2 - 2\, O_2} \quad (8)$$

Percentage of carbon in combustible =

$$\left[\frac{6\, (CO_2 + CO)}{0.525\, N_2 + 5\, CO + 4\, CO_2 - 2\, O_2} \right] \times 100 \quad (9)$$

Percentage of hydrogen in combustible =

$$\left[\frac{0.525\, N_2 - CO - 2\, (CO_2 + O_2)}{0.525\, N_2 + 5\, CO + 4\, CO_2 - 2\, O_2} \right] \times 100 \quad (10)$$

Ratio of carbon to hydrogen in combustible =

$$\frac{6\, (CO_2 + CO)}{0.525\, N_2 - CO - 2\, (CO_2 + O_2)} \quad (11)$$

The term combustible refers to the sum of the fixed carbon and the volatile combustible matter, as given by the proximate analysis. Or, it may be stated as the total weight of fuel less water and ash. In applying the formulas, the percentages of CO_2, O_2, CO and N_2 are inserted for the symbols and solved in the usual way.

It will be noted that the new formulas contain information not hitherto deduced from the flue-gas analysis, namely: water vapor in the gases of combustion and the proportions of carbon and hydrogen in the fuel. These items are to be regarded as only supplementary to the main object, which is to determine the weights of air and of the dry gases, as given by formulas (4) to (7).

Internal evidence of the consistency of the formulas and of the gas analysis may be had by summing up the weight of the products in two ways: first, 1 + air (4); second, dry gas (5) + water vapor (8). The two sums should be the same for consistency. A rigid check of the new formulas

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can be had from the ultimate analysis of the fuel, which permits exact computation of the theoretic air and of the ratio of hydrogen and carbon.

In conclusion, two illustrations will be given of the use of the formulas in interpreting gas analysis.

Example 1.—Semi-bituminous coal in a power boiler. Flue-gas analysis: $CO_2 = 11.8$; $O_2 = 7.7$; $CO = 0.2$; $N_2 = 80.3$.

	By Formula	
Air per pound of combustible	(4)	19.4 lb.
Dry gases per pound of combustible	(5)	20.0 lb.
Theoretic air per pound of combustible	(6)	12.7 lb.
Excess air used	(7)	54.0 per cent
Water vapor per pound of combustible	(8)	0.4 lb.
Carbon in combustible	(9)	95.6 per cent
Hydrogen in combustible	(10)	4.4 per cent
Ratio of carbon to hydrogen	(11)	21.8

Example 2.—Gasoline in a six-cylinder engine (1917). Exhaust-gas analysis: $CO_2 = 10.15$; $O_2 = 0.55$; $CO = 5.65$; $N_2 = 83.65$.

	By Formula	
Air per pound of combustible	(4)	13.65 lb.
Dry gases per pound of combustible	(5)	13.2 lb.
Theoretic air per pound of combustible	(6)	15.1 lb.
Excess air used	(7)	— 9.5 per cent
Water vapor per pound of combustible	(8)	1.4 lb.
Carbon in combustible	(9)	84.6 per cent
Hydrogen in combustible	(10)	15.4 per cent
Ratio of carbon to hydrogen	(11)	5.5

In commenting on these examples it may be stated that the ultimate analysis was not available; hence, the proportions of hydrogen and carbon could not be checked. However, using average values from handbooks, satisfactory agreement was obtained. The theoretic air by the new formulas was found to check well with that from the average ultimate analysis of the fuel.

A characteristic difference between the boiler furnace and the gasoline engine is shown by the excess-air items, 54.0 per cent excess in the furnace, and 9.5 per cent deficiency in the engine. The latter is properly indicated by a minus sign in formula (7).

The consistency check, based on the weight of the products of combustion, is satisfactorily met.

Example 1.—Air + fuel = 19.40 + 1.00 = 20.40
Dry gases + water = 20.00 + 0.40 = 20.40

Example 2.—Air + fuel = 13.65 + 1.00 = 14.65
Dry gases + water = 13.20 + 1.40 = 14.60

From these and many similar applications it has been fairly well proved that the formulas can be relied on for satisfactory results, provided that the gases have been carefully sampled and analyzed.

APPENDIX—DERIVATION OF FORMULAS

These formulas are deduced under certain limitations which may be stated as follows: (*a*) hydrogen in the fuel is assumed to be negligible in amount; (*b*) sulphur in the fuel is also assumed to be negligible in amount; (*c*) hydrogen, as used in the formulas, refers to the free hydrogen, $H - (O/8)$, or the portion of the hydrogen that requires air for its combustion. It is further assumed that the combustion is fairly complete, so that no unburned fuel is found in the products of combustion, except small amounts of carbon monoxide. With these assumptions complied with, the gases can be analyzed by the Orsat apparatus, and the results can be interpreted by the formulas.

In the combustion process the carbon and the hydrogen of the fuel unite with the oxygen of the air, yielding products that may be designated as follows:

Carbon dioxide	CO_2
Carbon monoxide	CO
Water vapor	H_2O
Free oxygen	O_2
Nitrogen	N_2

The percentage volumes of four of these products are determined by the Orsat apparatus, while one, water vapor, escapes without measurement. It is convenient to denote the percentage volume by the symbol. Thus, N_2 denotes not only nitrogen, but refers to the percentage of it given by the analysis, whenever it is used in a formula.

The weight of the various products can be expressed in terms of the volume by means of the appropriate atomic weight numbers. Knowing the weight of oxygen or nitrogen, the weight of the air can be found by dividing the oxygen by 0.23, or by dividing the nitrogen by 0.77. The atomic-weight method fails in the case of hydrogen, because its product, water vapor, is not included in the exhaust analysis.

The weight of hydrogen in the fuel can be arrived at indirectly, by equating two expressions for the total weight of air. From the nitrogen,

$$\text{Weight of air} = 28\ N_2/0.77 \qquad (12)$$

From the products CO_2, CO, H_2O, O_2,

$$\text{Weight of air} = \frac{32\ CO_2}{0.23} + \frac{16\ CO}{0.23} + \frac{8\ H_2}{0.23} + \frac{32\ O_2}{0.23} \qquad (13)$$

Equating the two expressions and solving for hydrogen,

$$H_2 = 1.05\ N_2 - 4\ (CO_2 + O_2 + CO/2) \qquad (14)$$

The following can be written directly from the atomic weights:

$$\text{Weight of carbon} = 12\ (CO_2 + CO) \qquad (15)$$

$$\text{Weight of combustible} = 1.05\ N_2 + 10\ CO + 8\ CO_2 - 4\ O_2 \qquad (16)$$

$$\text{Weight of dry gases} = 44\ CO_2 + 28\ CO + 32\ O_2 + 28\ N_2 \qquad (17)$$

$$\text{Air theoretically required} = \frac{12\ (CO_2 + CO) \times 32}{12 \times 0.23} + \frac{8\ H_2}{0.23}$$

Inserting H_2 from (14),

$$\text{Weight of air theoretically required} = 36.5\ N_2 + 69.6\ CO - 139.2\ O_2 \qquad (18)$$

The weight of water vapor is nine times the weight of hydrogen; hence,

$$\text{Weight of water vapor} = 9.45\ N_2 - 36\ (CO_2 + O_2 + CO/2) \qquad (19)$$

The foregoing weights are all expressed in the same units; hence, they are comparable for derivation of formulas, as indicated below. In this list the numbers in parentheses between the signs of equality refer to the expressions in the body of the paper and the appendix.

Weight of air per pound of carbon =

$$\frac{(12)}{(15)} = \frac{3.03\ N_2}{(CO_2 + CO)} \qquad (1)$$

Dry gas per pound of carbon =

$$\frac{(17)}{(15)} = \frac{11\ CO_2 + 8\ O_2 + 7\ (N_2 + CO)}{3\ (CO_2 + CO)} \qquad (2)$$

Ratio of the air actually used to the air theoretically required =

$$\frac{(12)}{(18)} = \frac{N_2}{N_2 - 3.78\ (O_2 - CO/2)} \qquad (3)$$

Weight of air per pound of combustible =

$$\frac{(13)}{(16)} = \frac{18.3\ N_2}{0.525\ N_2 + 5\ CO + 4\ CO_2 - 2\ O_2} \qquad (4)$$

Dry gas per pound of combustible =

$$\frac{(17)}{(16)} = \frac{22\ CO_2 + 16\ O_2 + 14\ (N_2 + CO)}{0.525\ N_2 + 5\ CO + 4\ CO_2 - 2\ O_2} \qquad (5)$$

Theoretical air requirements per pound of combustible =

$$\frac{(18)}{(16)} = \frac{18.3\ N_2 + 34.8\ CO - 69.6\ O_2}{0.525\ N_2 + 5\ CO + 4\ CO_2 - 2\ O_2} \qquad (6)$$

Per cent of excess air =

$$\frac{(12)-(18)}{(18)} = \frac{69.6\ O_2 - 34.8\ CO}{18.3\ N_2 + 34.8\ CO - 69.6\ O_2} \quad (7)$$

Water vapor per pound of combustible =

$$\frac{(19)}{(16)} = \frac{4.77\ N_2 - 9\ CO - 18\ (CO_2 + O_2)}{0.525\ N_2 + 5\ CO + 4\ CO_2 - 2\ O_2} \quad (8)$$

Percentage of carbon in combustible =

$$\frac{(15)\times 100}{(16)} = \frac{6\ (CO_2 + CO) \times 100}{0.525\ N_2 + 5\ CO + 4\ CO_2 - 2\ O_1} \quad (9)$$

Percentage of hydrogen in combustible =

$$\frac{(14)\times 100}{(16)} = \left[\frac{0.525\ N_2 - CO - 2\ (CO_2 + O_2)}{0.525\ N_2 + 5\ CO + 4\ CO_2 - 2\ O_2}\right] \times 100 \quad (10)$$

Ratio of carbon to hydrogen in combustible =

$$\frac{(15)}{(14)} = \frac{6\ (CO_2 + CO)}{0.525\ N_2 - CO - 2\ (CO_2 + O_2)} \quad (11)$$

RURAL CREDITS

FARMING is a small-unit business. In 1920 the 6,448,343 farms of this Country contained an average per farm of 148.2 acres, and the average value per farm of all farm property, including land, buildings and implements, was $12,084. Although the capacity to withstand adversity is increased by this multiplicity of units relative to the aggregate output, some obvious advantages of large producing units, characteristic of so much of the Country's industrial production, are not shared in general by the farmers.

The Joint Commission of Agricultural Inquiry in its report to Congress in 1921, said:

> If we consider that the farmer could make 5 per cent on his total property by investing it elsewhere and that only the residue of his income is payment for his efforts, the following conclusions follow for the year 1913: Had the farmer gone to work as a farm laborer, his average labor income would have been $328, instead of $444. Had he worked instead in the mining industry at the average earnings of the employe in that industry, he would have received $755, or about 70 per cent more than his actual labor income. The farmer in 1918 had an income of $1,278 resulting from his labor, risks and management. Had he worked in the mining industry for the average earnings of the employes in that industry, he would have received a wage of $1,280 or almost exactly the amount of his actual earnings. Had he worked as an employe in the railroad or banking field, he would have made materially more for his labor than he did on the farm, but he would have been worse paid had he received the average earnings of those employed in factories, in public utilities, in Government or in unclassified industries.

The purpose of the United States Warehouse Act, which became a law in 1916, was to establish a form of warehouse receipt of cotton, grain, tobacco, wool and flaxseed that might make these receipts readily negotiable as delivery orders or as collateral for loans. Accordingly, acceptable warehousemen are licensed for the storage of these products. The rapid growth in the number of warehouses licensed under the Act is evidence of the need for the services which they are now rendering.

Information about conditions in the consuming markets is regularly accessible now but generally speaking the sellers of farm products that have world markets are not so well informed about consumption as are the buyers about production. It is the opinion not only of farmers, but of competent students of marketing problems, that in the distribution of farm products there is an excessive duplication of middlemen, with a tendency to depress unduly the prices paid the producers and to raise the costs to the consumers. Doubtless much can be done to eliminate unnecessary services in the distribution of farm products, and of other commodities as well.

The first practical effect of the discussion of rural credit problems in the period between the panic of 1907 and the outbreak of the World War, in the form of legislation to provide new credit facilities for farmers on a national scale, came with the passage of the Federal Reserve Act in 1913. The law made agricultural paper, that is, notes, drafts and bills of exchange, drawn or issued for agricultural purposes or based on live stock, with a maturity not exceeding 6 months, eligible for discount by Federal Reserve Banks. Other eligible paper was restricted to a maturity not exceeding 90 days. Thus, the law specifically recognized the difference between acceptable maturities for agricultural paper on the one hand and industrial and commercial paper on the other. The fact that most of the State banks have not become members of the Federal Reserve System, from choice or because of lack of qualification, has greatly restricted the proportion of the aggregate agricultural bank loans that may be discounted by Federal Reserve Banks. Moreover, the range of maturity of eligible agricultural paper is regarded in many quarters as too narrow.

Some light is thrown upon the question of the comparative amounts of credit extended to agricultural and to all other classes of borrowers by investigations for the Joint Commission of Agricultural Inquiry, which indicated that "in general the expansion in the agricultural States during the period of inflation was at least as great, if not greater, than in the industrial States." It was found also from a study of reports of about 9500 member banks that "between May 4, 1920 and April 28, 1921, the loans and discounts of banks in agricultural counties throughout the country declined $36,500,000, or slightly more than 1.2 per cent; the loans and discounts of banks in semi-agricultural counties declined $18,700,000, or 1.3 per cent; and the loans and discounts of banks in non-agricultural counties declined $827,100,000, or 5.6 per cent. The borrowings from the Federal Reserve Banks by banks in agricultural counties increased $127,600,000, or 56.6 per cent; borrowings by banks in semi-agricultural counties remained practically stationary; and borrowings by banks in non-agricultural counties declined $629,100,000, or 28.5 per cent."

The Federal Farm Loan Act of 1916 provided for the establishment of 12 regional Federal Land Banks. Loans running for not more than 40 years and not less than 5 years are made on the security of first mortgages on farm land through national farm-loan associations of 10 or more farmers each, or through specified agents. The maximum loan to an individual is $10,000, and the maximum interest that may be charged on loans is 6 per cent, but in no case is the rate to exceed by more than 1 per cent the rate paid on the last issue of bonds for raising the funds to be loaned.

The capital stock of the banks is owned by the Government, national farm-loan associations, borrowers through agents and individual subscribers. On Oct. 31, 1922, the Government's stock had been reduced to $4,264,880, of a total of $35,256,730. Nearly all of the remaining stock was owned by loan associations. At that time the net mortgage loans by the banks outstanding totaled in round numbers $606,000,000, and their farm-loan bonds authorized and issued amounted to $641,000,000. These bonds and the mortgages on which they are based, as well as the capital stock of the banks, are exempt from taxation.

Besides the Federal Land Banks, the Act permits the establishment of Joint-Stock Land Banks and authorizes them to lend directly to borrowers on farm mortgage security and to issue farm-loan bonds. The number of these banks, 61 in November, 1922, was more than doubled in the last year.

From Jan. 4, 1921, to Nov. 30, 1922, the War Finance Corporation had approved advances to banks, live-stock loan companies and cooperative marketing associations, for agricultural and live-stock purposes, in 37 States, amounting to $433,000,000.—*Guaranty Survey.*

1922 and the Motorboat Industry[1]

By H. H. Brautigam[2]

During the year just ended, great progress has been made in the motorboat industry in this Country. This statement applies with equal force to the commercial and the pleasure aspects of the industry. Marked developments in power, as well as an advance in construction, have made the past year a notable one. Briefly, the outstanding features seem to have been the greater development and a more widespread acceptance of the standardized boat, the production of high-power engines of the Diesel type for use on commercial vessels in place of steam, the noteworthy improvement in the design and the efficiency of the high-power, high-speed engine and the further perfection and development in the use of the outboard engine.

The outboard engine, when it first came into use some years ago, was little more than a toy designed for boys to place on a rowboat. But gradually it has been developed and made more and more reliable. With their greater reliability a rapidly increasing demand for engines of this kind has arisen. During the past year a number of new companies have entered the field, with the result that the outboard engine is used constantly on the tenders of yachts in place of man-rowing power.

While one or two builders have, by the use of aluminum, succeeded in making very light machines of this type, the question of light weight is not given so much consideration now that the demand is for a steady, reliable engine. Cylinder dimensions have been increased, which of course gives the engine more power and makes it more serviceable. There is also a tendency to make two-cylinder powerplants instead of the one-cylinder outboard engines that were first constructed. Both battery and magneto ignition are used. Besides being used on the tenders of yachts and Government boats, these little engines have proved a great boon to the rod and line fisherman. On Chesapeake Bay they are used almost exclusively in trolling for rock fish.

While the cost of fuel has exerted a tremendous influence in the building of engines for the medium-size and the large boats of both the pleasure and the commercial types, it has had little or no effect upon the production of the small, low-power gasoline engine used for small passenger and pleasure boats. On these smaller machines where the cost of fuel consumed is small, and therefore less of an item in the expense of operation, the demand has been for a better, cleaner and quieter engine. The high development of the four-cylinder four-cycle engine has met this demand. The extent to which this development has been carried by the builder can be seen readily by comparing the engines of this year's construction with those produced 5 or 6 years ago. Within the past 12 months great advances have been made in the production of automotive apparatus, in castings, crankshafts and the like, and the engine builder in many instances, by availing himself of these improvements, has been enabled to decrease his production costs to the ultimate benefit of the purchaser.

The past season witnessed the introduction to the yachting public of a number of high-speed marine engines with horsepowers ranging from 50 to 200 and more. These engines, masterpieces of design and construction, have already given a good account of themselves in every test to which they may have been put. Some of these engines were installed in high-speed runabouts and were subjected, during the various race-meets held in the past season throughout the Country, to a series of grueling tests. Others were installed in cruising boats of various sizes where sturdiness and reliability were vitally necessary. In every instance these engines performed fully up to and beyond the claims of their builders. Greater things are expected of these engines during the coming year, as the builders, with all of this experience behind them, have been ceaselessly experimenting and testing with the sole object in view of being able to offer to the public a high-speed engine of the first grade with unquestioned power and endurance as well as the greatest reliability.

The larger high-power engines of the Diesel type have in the past year been advanced considerably in efficiency and are gradually displacing steam in commercial vessels in which a great amount of power is required, such as tugboats, coasting barges, tankers and even transoceanic freight vessels of large tonnage. Around New York Harbor tugboats are being constantly equipped with these engines for harbor usage and for towing through the New York State Barge Canal. Recently they have been installed in all the tugs of the Transmarine Corporation. On the Great Lakes they are being used in grain-carrying hulls. On the Pacific Coast, where the tendency to use them in place of steam is even greater than on the Atlantic Coast, barges and freight vessels are constantly equipped with them. Their advantages are many and obvious. They have proved highly efficient and powerful. They cut down the cost of transportation by being more economical than steam in the man-power and fuel needed to run them. And their usage makes for a cleaner boat, for they do away with the stoker and the annoyance of continually emptying ashes. But one engineer is needed to run them in place of the engineer and two or three firemen needed with a steam engine. The fuel for these engines is easily obtained and the power plant itself requires less space than a steam engine, aside from the coal that must be carried with the latter.

Developments in Boat Construction

In boat construction the past year showed three outstanding features, the development of the luxurious type of houseboat, the improvement of the standardized cruiser and the wide acceptance of the V-bottom speed-boat. The houseboat, in the past nothing more than a flat-bottomed barge with a clumsy square house built upon it, has in recent years been changed into the power-houseboat. Many of these boats, especially the ones designed and built for the winter season in Florida and other Southern waters, are exceedingly comfortable, luxurious vessels. While they are built primarily for comfort, they are also very able vessels. Many of them have very good speed, making from 9 to 14 m.p.h. With

[1] Annual report of the Second Vice-President representing marine engineering.

[2] M.S.A.E.—President, Bridgeport Motor Co., Bridgeport, Conn.

these boats the clumsiness of the old-fashioned houseboat has been entirely eliminated. They are now designed with no little thought of appearance, show very good lines and are often just as graceful as the yachts surrounding them. Such houseboats are capable of cruises from our coasts to the beautiful islands of the West Indies where many of them can now be found every winter. In fact, in this Country, it has become the custom to start from the Great Lakes or the North Atlantic coast in one of these cruising houseboats about the first of November, travel down the coast to Florida, Cuba, Jamaica or the Virgin Islands and spend the winter months in the warmer waters. To just what extent prohibition in the United States has tended to develop this custom would be hard to estimate.

The interior fittings of these houseboats have become really magnificent. The craft are equipped with every imaginable device that could possibly add to the comfort of the owner and his guests. Immense saloons on the main deck serve the purpose of not only lounging rooms, but in many cases this part of the houseboat is equipped with pianos, and sometimes large electrically operated organs, and the saloon, with its smoothly polished floor, is readily convertible into a ballroom. Either a complete wireless outfit or at least a small receiving radio-set is found on practically all of these boats. Bathrooms are often tiled and fitted with both hot and cold showers. Galleys contain iceboxes of no mean dimensions and are often equipped with the latest electrical cooking devices. Lighting is almost invariably by electricity and steam or electric heating, a decided comfort on a chilly morning, is used. Bedrooms, living rooms and other quarters are often finished in mahogany and furnished with exquisite taste. In fact, many of these boats are so luxurious that living in them is as easy as living at one of our best hotels.

The standardized cruiser that made its appearance in greater numbers last year is a successful attempt to meet the demand for boats from people of moderate means. Many companies are now building such stock boats. Some of them are as small as 25 ft. in length, while others run up to 65 ft. An average size seems to be between 30 and 40 ft. overall by 8 to 10 ft. beam. Several builders are now putting out such a stock boat for from $3,000 to $5,000. These boats have well-built cabins and are equipped with every convenience required for an extended cruise. Boats of this type have shown great development within the past year. They have gradually been given more freeboard, so as to sit higher out of the water until now they are very able and seaworthy boats.

Boats of this type are always well powered with fully equipped engines. Most of the engines have electric starters and generators for developing current for the electric systems. Such cruisers are all one-man-controlled boats, the engine being started and controlled by the man at the steering-wheel. Their interiors generally consist of the cabins, bath, kitchen and engine-room. For small families or parties of three or four the standardized cruiser is an ideal boat, and one that is well within the means of the average boat enthusiast. Many of these cruisers will be seen this winter in Florida waters, a large number of them having traveled from our Great Lakes section by way of the Erie Canal, the Hudson River and the inland route along the Atlantic Coast. In Europe they would make excellent boats for cruising around Southern Italy, Sicily and the Mediterranean.

Where speed is a consideration the V-bottom boat is becoming more and more popular. In the races of the past year it repeatedly demonstrated how well deserved is this popularity. Not only does such a boat show more speed than the round-bottom type but it is much simpler in construction.

One or two other features of the industry deserve mention. There are, for instance, the rapid development of the auxiliary sailing boat, and the increasing popularity of the express runabout, a small open boat of perhaps 30 to 35 ft. that is capable of speeds up to 50 m.p.h. These runabouts are equipped with high-speed engines of from 50 to 200 hp. They can be handled readily by one man and are gradually being developed for fast messenger service.

In general, the tendency today is to meet the demand for a less expensive boat, at no sacrifice of speed, comfort or efficiency, by the use of standardized parts in the engine and the production of a standardized boat. In fact, the price of a boat of good construction is down to a figure that is well within the reach of the average man. In this Country today the statement, "a boat for everybody," can be applied much more truthfully to motorboats than a corresponding statement can be applied to automobiles. A complete motorboat of the small open type, equipped with a serviceable engine, can be bought new at present for less than $300, a figure considerably lower than the price of even the cheapest automobile on the market.

Cyrus H. K. Curtis, owner and publisher of the *Saturday Evening Post*, spends the greater part of his time aboard his wonder yacht Lyndonia. In an interview just recently at Miami, Fla., where the Lydonia is now stationed, Mr. Curtis said:

> Yachting pays in a score of ways. They say you cannot have your youth back, once you have passed the milestone of maturity and age. I disagree with that. I have had my youth back and still have it. The sea knows no age, and those who live on it partake in time of the same quality of strength and restful motion that is part of the ocean. I have never felt better in my life than I do today. I know it is the yacht that is doing this for me. Life seems happier on this deck, problems simpler and a cigar tastes better.

A NEW TYPE OF RAIL-CAR

In connection with the discussion on rail-cars, reported in The Journal for December, 1922, attention is drawn to the detailed description in *The Engineer* for Dec. 29, 1922, of the European Diesel-electric car mentioned in Roy V. Wright's paper. This rail-car has an overall length of 70 ft., and weighs, empty, 65.52 tons; it has a seating capacity of 69. The powerplant is a six-cylinder, four-stroke Diesel engine developing 200 hp. at 440 r.p.m., running on tar-oil injected directly into the cylinders without the use of air. The returns for a full month's working in branch-line service conditions on a 46-mile section show an average fuel-consumption of 0.043 lb. per ton-mile, including the fuel used when the car is engaged in switching service, providing compressed-air for the airbrake system and recharging the storage-batteries.

The trial runs made on a branch line of the Swiss Federal Railroad system are reported as having been satisfactory in every respect, and it is anticipated that this rail-car will show a considerable saving as against the running costs of the ordinary electric train.

Stationary Internal-Combustion Engineering Developments[1]

By C. B. SEGNER[2]

THE name Stationary Internal Combustion Engineering, as applied to the work of a group in the Society, is somewhat anomalous, as most of our members intended to be included in this classification are interested principally in the small general-purpose portable and semi-portable engines used for driving farm machinery, concrete-mixers, gasoline hoists, pumps, and apparatus of similar nature. The "real" stationary engines are those used for driving factory apparatus, electric generators, rolling-mills, and other heavy machinery. They form the basis of a very important industry and their design and construction should be of interest to all our members, but the activities of the group of the Society of which I have been vice-president, seem to have been confined very largely to the smaller types of engine mentioned.

The general-purpose engines have been developed to a wonderful degree of simplicity, and American methods of production have brought their cost very low. The majority of them are of the single-cylinder medium-speed type, using magneto ignition and being supplied with a throttling governor and with a carbureter or mixing-valve that permits the use of either kerosene or gasoline as a fuel. Developments of this class of engine are progressing along several different lines. Existing models are being made more reliable by the use of better magnetos, carbureters, and lubricators.

Some of the work formerly handled by the general-purpose engine is now being done by special engines designed for specific purposes. Among these are the engine for the isolated electric lighting-plant, the little engine used for driving the knotting mechanism on grain binders, and the farm pump engine. I believe, however, that the most important trend of development is the use of multiple-cylinder automobile or tractor type engines, especially in the larger sizes, above 6 or 8 hp. These engines are sold as complete power units with all accessories, such as magneto, carbureter, governor, fuel-tank and power takeoff, all enclosed in a metal housing. These light, convenient and reliable powerplants are coming more and more into favor, especially for driving pumps and hoists, and for industrial work that demands mechanical reliability.

The single-cylinder general-purpose engine, because of its low cost and simplicity, will without doubt be built and sold in large quantities for many years but, if I may venture a prediction, I would say that the principal developments will be in the direction of special engines for specific purposes and of units for industrial purposes. In this event the engines will become more nearly like the automobile and tractor engines in design and equipment. This constitutes another argument why all engineers and production men engaged in the "stationary internal-combustion engineering" industry should be members of the Society of Automotive Engineers, in which are available the benefits of the experience gained in the development of automobile and of aircraft engineering, as well as of the S.A.E. Standards for materials and dimensions of various component parts and accessories of engines.

[1] Annual report of the Second Vice-President representing stationary internal-combustion engineering.

[2] M.S.A.E.—Vice-President and general manager, Domestic Engine & Pump Co., Shippensburg, Pa.

OBITUARIES

ALBERT H. MILLER, research engineer for the Nicetown Works of the Midvale Steel & Ordnance Co., Philadelphia, died at his home in that city on Jan. 11, 1923, aged 42 years. He was born on Aug. 27, 1880, at Philadelphia, and following his public school education matriculated at the University of Pennsylvania in 1897, being graduated in 1901 with the degree of Bachelor of Science in mechanical engineering. In 1908 he took a special course in heat-treatment and the structure of steels at the Sorbonne, in Paris, France.

Mr. Miller made a life study of the scientific features of steel manufacture. He was particularly skillful in analyzing steels microscopically, and in designating appropriate heat-treatments to secure the desired physical properties. At the time of his death he was in charge of the development of new products.

He was a member of the American Society for Steel Treating, and at times read papers upon metallurgical subjects, his latest being one on the Commercial Heat-Treatment for Structural Steels, read before the Washington section of the American Society of Mechanical Engineers. He was also a member of the Philadelphia Engineer's Club and of other fraternal and social organizations. He was elected to Member grade in the Society on March 7, 1922.

ALFRED THOMAS STURT, chief engineer of Durant Motors, Inc., Long Island City, N. Y., died of scarlet fever on Jan. 23, 1923, aged 44 years. He was born at Flint, Mich., in 1878 and received his scholastic education in the Flint high school. Entering the service of the Buick Motor Co. in 1903, he served it progressively until 1912, when he became assistant engineer for the Dort Motor Car Co. In 1913 and 1914 he was chief engineer for the Mason Motor Co. and also chief engineer of the Chevrolet Motor Co. in 1915, later forming a connection with Durant Motors at the time of its organization. He was elected to Member grade in the Society on Feb. 16, 1916.

SOCIETY MEETINGS

SHOP AND ENGINEER MUST COOPERATE

Detroiters Say Team-Work Is Essential in Successful Manufacturing Organization

The promotion of a better understanding between the factory-man and the engineer is a theme rather worn with discussion, but it served as the topic of a lively and successful meeting of the Detroit Section on Feb. 2. Incidentally, any effort made toward accomplishing the ideal of arm-in-arm team-work between the designer and the producer is akin to the times; there has never been such a decided tendency in this direction since the creation of the first motor-car as there is at the present time.

L. V. Cram, production engineer with the Chevrolet Motor Co., read a paper in which he stressed the value of a more intimate contact between the engineering and the manufacturing departments. He argued that engineering service must not be considered complete when it provides satisfactory drawings, bill-of-material and an efficient alteration system. There is a fourth requisite equally important, the presence of an engineer of judgment in the shop all the time, keeping pace with production development, making decisions, giving courteous advice and seeing that proper record is made of all improvements in method or product that originate in the shop. No producing organization stands still for a minute; ideas are germinating all the time in the interest of progress and many of these are worthy of adoption. It is the function of the engineering department to seek these out, pass judgment on them and effect their application. This necessitates the engineer's presence in the shop. It is a mistake to take a mechanic from his machine into a private office in the hope of securing his ideas; the change in environment makes him self-conscious and, usually, silent. Cultivate the spirit of cooperation in the shop, encourage the submission of suggested improvements, and the constantly improving product will reflect credit on the engineer eventually.

George E. Goddard read a paper prepared by H. W. Hayes in which the method of effecting alterations in the Dodge Bros. factory was explained. It was of particular interest to learn that a small number of altered parts or units were run through the complete manufacturing and assembly routine before an alteration was made effective definitely. This procedure assures the clearing up of many unanticipated interferences and objections before the alteration takes final form, thus eliminating disagreeable production tie-ups when the change becomes effective.

Organization Likened to Football Team

Walter Fishleigh, of the Ford Motor Co., gave an inspiring and forceful talk on the oft-ridiculed philosophy of cooperation. He stated that the factories which seem to accomplish the greatest success are often those with the most meager and undeveloped system and organization. It was his belief that most executives underestimate the importance of morale and teamwork in the proper functioning of an organization. System and organization rules were likened to the signals of a football team; they are an important accessory, but without team-play are ineffective. Mr. Fishleigh is of the opinion that all engineers are production men in this sense. Engineering "departments," considered as units set apart and separated from the shop by frosted glass partitions, should not exist. Engineers must come from behind these partitions, interest themselves in the shop and get acquainted with its men. This is fundamental to team-work and true organization. Too many partitions are directly responsible for the feeling in some production departments that cars must be built "in spite of the engineers."

The words "change" and "alteration" should be discouraged; substitute in their stead the term "improvement." Mr. Fishleigh remarked that any change which is not an improvement lacks justification. No successful product endures without constant improvement and this of necessity means constant alterations.

K. L. Herrmann, O. E. Hunt, T. J. Litle, Jr., and others participated in the discussion following the papers.

Painting, the Topic of March Meeting

L. V. Pulsifer, chief chemist, Valentine & Co., will address the Detroit Section at its meeting on Friday, March 2. His topic will be "Painting Practice and Problems from the Chemist's Viewpoint." The meeting will be held in the General Motors Building, starting at 8 o'clock and will be preceded by an informal dinner at 6:30 p. m.

DAYTON HAS INTERESTING MEETING

Members Hear Talks on Alloy-Steel Valves and Wire, Steel and Wood Wheels

The Dayton Section tried a new feature as a part of its meeting program on Feb. 20, and it met with considerable approval. Immediately following the dinner, informal talks were given on the relative merits of various forms of automotive wheels. Louis H. Rogge championed the wire and metal-spoke wheel, F. H. Walkley supported the cast-steel wheel, and Mr. Weisner spoke for the wood-spoke and wood-disc wheel.

Glenn A. Toaz read an informative paper on valve problems encountered in the automotive engine. His talk included historical sketches of different types of valve that have been used in internal-combustion engines and discussion of their limitations. He traced the development from the cast-iron valve up to the recent silchrome alloy-steel type. Slides were shown illustrating the condition of the different valves and valve steels after a life-test in engines and after oxidation tests in furnaces.

RIVER BOATS USE OIL ENGINES

Engineer Describes New Tow-Boats Developed for Freight Traffic on Mississippi

Two of the newer applications of the internal-combustion engine were considered at the meeting of the Minneapolis Section on Feb. 7. Papers were read on the Mississippi River tow-boat and the motor rail-car. The former paper was read by J. Brodie, engineer of the River Transit Co., St. Paul, Minn. He said that the following matters must be considered in the design of freight-carrying boats due to Mississippi River channel conditions: first, the maneuvering ability of the stern-wheel steamboat of the old type is primarily essential for moving any kind of load on the river; second, adequate protection must be given the cargo in all kinds of weather; third, cheap and dependable methods must be devised for the handling of freight at the terminal; and fourth, boats must be operated with such frequency that sailing dates will be close enough to make the service attractive in the way of early delivery for shippers. Mr. Brodie felt that the fleet of tow-boats built by the Government at an expense of $3,500,000 was not entirely practical since the channel is too narrow and too crooked to steer long tows through without getting them stuck. These Government barges have a capac-

ity of about 1600 tons each and the tow-boats, equipped with 2000-hp. engines are capable of moving three or four barges at a time.

Mr. Brodie discouraged the old practice of handling passengers and freight on the same boat; the two types of traffic cannot be handled together profitably because of the frequent stops necessitated by the freight service with uncontrollable delay at each stop. He believed that the increased use of motor trucks and the extension of good roads are discouraging to short water-hauls but advantageous to long water-hauls.

For the present at least, Mr. Brodie recommends that river freight barges be about 300 ft. long and 80 to 100 ft. wide, with a draft not exceeding 3 ft. The size of these boats could be increased with the development of traffic, but if the most efficient craft is put on the river at the start, the amount of freight that the carrier can get will not be sufficient to secure maximum efficiency from the craft. There is some question whether a self-propelled boat or a tow-boat with barges is more practical. The barge system is more flexible since barges can be left at docks for loading or unloading and the tow-boat itself can be kept in operation continually. With the barge system, a single crew, specialized in the moving of barges with an efficient tow-boat, can move considerably more freight than with any other method. This is due largely to the fact that one specialized crew handles operation and another the loading and unloading of the barges. The self-propelled boat has the advantage of being able to move anywhere as soon as its load is removed; sailings will be more frequent and this feature alone is sufficient in some cases to demand the use of the self-propelled boat. Its greatest disadvantage is that the navigating crew and engines are idle while the boat it at the dock.

With the stern-wheel tow-boat, the slow motion of the paddle-wheel makes the application of the direct-connected steam-engine by far the most simple mechanism. The weight of the boiler, engines and fuel in such a boat is a great disadvantage; in addition, fueling with coal ties-up the equipment too long a time. The small amount of power required on each unit makes the oil-burning internal-combustion engine readily adaptable. The possibility of one man operating both the steering mechanism and the engine is another feature favoring the automotive engine. The transmission of power is the big problem when utilizing the internal-combustion engine. This is largely due to the fact that the use of propellers in tunnels in the hull of the boat has not proved entirely satisfactory. One of the necessities in tow-boat operation is ability to back with a strong sidewise force and this quality is not pronounced in the tunnel-propeller boats. It is generally agreed that there is no means of propulsion as effective in steering and stopping as the stern wheel with rudders both in front of and behind it. Mr. Brodie's organization is planning to use a tractor transmission between the engine and the paddle-wheel, throwing the engine out of engagement and applying brakes to the paddle-wheel until it is stopped; the clutch can then be engaged for driving in the reverse direction. He intends to use a 75-hp. engine that will be capable of driving the boat at a speed of 8 m.p.h. in still water. This speed is about as great as can be obtained efficiently during the low-water periods on the Mississippi River and Mr. Brodie considers any additional power would be wasted.

The paper on motor rail-cars was read by E. Russell Greer, engineer of the Service Transfer Co., St. Paul, Minn. This paper was principally a resume of the material already published on the motor rail-car and included a description of the car designed by C. O. Guernsey and operated by the Great Northern Railway. This particular car is mounted on two trucks each having four wheels; the wheels have rubber cushions mounted between the steel rim and the flanges to absorb shocks. All four wheels of the front truck are positively driven by a four-cylinder engine developing 66 hp. The car seats 44 persons and is provided with baggage space; it runs 200 miles a day and is operated by a crew of two men. It was interesting to note that the car does not carry the standard railroad couplers which weigh 400 to 500 lb. apiece. A standard railroad airbrake system is used, the compressor being driven by the engine. The engine installation is arranged so that the entire powerplant can be removed from the car for overhauling and replaced with a new unit without tying-up the entire equipment.

The next meeting of the Minneapolis Section is scheduled for the evening of March 7, when Charles Boehnlein of the University of Minnesota faculty will outline the Development of the Modern Airplane. The meeting starts at 8 o'clock in the Builders' Exchange headquarters.

NEW HEAD-LAMP ILLUMINATION CHART

A new method of graphic representation of head-lamp illumination will be presented as part of a paper on Road Lighting to be read by F. H. Ford at the Mid-West Section meeting on the evening of March 23. Mr. Ford has experienced difficulty in presenting comparative data on non-glare lens effectiveness to engineers who have never used photometric charts. He has developed a new chart that presents these data in a simplified form showing clearly the variations in light intensity. Other interesting material on lenses, reflectors and road-illumination will be a part of the paper. The meeting will be held in the rooms of the Western Society of Engineers, Monadnock Building, starting at 8 o'clock.

TRUCK OPERATION TO BE FEATURED

Society Meeting at Cleveland in April Appeals to Operators and Manufacturers

The Meetings Committee has set the dates of April 26 to 28 for the National Meeting on Automotive Transportation. The Hotel Winton has been selected as headquarters for the meeting. It is centrally located and has a large garage adjacent to it where members driving to the meeting can store their cars.

Several papers have been definitely secured by the Committee for presentation at the Meeting. F. C. Horner, motor transport engineer with the General Motors Corporation, will describe some of the successful methods of operation being practiced in large European cities. This paper will be accompanied by numerous stereopticon illustrations and motion pictures. Types of bodies, loading and unloading equipment, and methods of routing and dispatching will be described by him. A second paper on motor-truck operation is being written by S. G. Thompson, chief transportation engineer of the White Motor Co., in collaboration with A. J. Scaife. This paper will describe methods of controlling the operation of a fleet of motor vehicles and include the practices of some of the most successful motor-transport organizations.

Major Brainerd Taylor, of the Motor Transport Corps of the Army, will read a paper describing an emergency system of motor-truck transportation that the Army was prepared to set up and operate in case of failure of the national transportation system during the railroad strike of 1922. This paper includes much of the experience of the Army transport officers resulting from the stupendous task of carrying on the truck transportation of the Service of Supply in France during the War. S. Von Ammon, of the Bureau of Standards at the City of Washington, will read a paper on the motor-truck axle tests that have been conducted by the Bureau. These tests have resulted in the gathering of extremely valuable data on the efficiency of motor-truck axles. Prof. W. E. Lay, of the University of Michigan, will contribute a paper describing some of the motor-truck testing work that has been done by the University staff to determine the gradient of highways that will be conducive to maximum economy of vehicle and road when the two are considered jointly.

Several other valuable papers are being considered for the program of this Automotive Transportation Meeting. It is evident that the sessions will contain much valuable material for both the constructor and the operator of trucks. It is expected that many motor-truck operators will attend

the meeting, particularly railroad representatives. Watch your future issues of the *Meetings Bulletin* for further details of the program. In the meantime, make arrangements to be in Cleveland on April 26 to 28.

SPRING LAKE SUMMER MEETING SITE

Jersey Coast Resort Selected Because of Its Unusually Attractive Features

The Summer Meeting of 1923 will be held at Spring Lake, N. J., June 19 to 23. This announcement was made by Mason P. Rumney, chairman of the Meetings Committee, at the Chicago Dinner and in a recent issue of the *Meetings Bulletin*. The selection was made after a careful canvass of all other available resorts in the East and Middle West. To those who strongly recommended a return to White Sulphur Springs it should be stated that the West Virginia resort could not accommodate us this year because its building program involves the razing of the White, thus limiting attendance to the capacity of the Greenbrier. The Committee feels that Spring Lake possesses the meeting and sport facilities of White Sulphur Springs, with the added attractions that are a part of a great seashore resort.

Spring Lake is situated on the Atlantic Coast between the better-known Atlantic City and Asbury Park. It has all of the climatic and geographical advantages of these two resorts without the congestion and bustle. The Hotel Monmouth and the Essex and Sussex are comparable with the finest resort hotels along the coast; a majority of the rooms have private bath. Spring Lake is easily accessible by rail through the New York City and Philadelphia terminals, being only two hours from these cities. The Society has secured reduced-fare concessions from the railroads from nearly all points in the automotive districts east of Chicago. Recreational facilities at Spring Lake include two 18-hole golf courses, numerous tennis-courts, baseball field, ocean bathing, swimming-pool, trapshooting and saddle horses. The climate in June is moderate.

Special issues of the *Meetings Bulletin* will reach the entire membership in advance of the Summer Meeting and to these will be left the task of giving in picture and printed word all of the attractive features of Spring Lake, and the important engineering and business sessions that will be arranged as a part of the Summer Meeting.

BUFFALO SECTION MARCH MEETING

J. Edward Schipper, technical writer, will address the meeting of the Buffalo Section on the evening of March 16. He will present a study of the trend in passenger-car development as exemplified by the New York City and Chicago Show exhibits. The meeting will be held at the Buffalo Engineers' Club in the Iroquois Hotel, starting at 8 o'clock.

GOVERNING FACTORS IN AUTOMOBILE SERVICE

Inspiring Papers and Discussion at Chicago Service Meeting

It is obvious that the prestige and lasting success of automotive companies, particularly those engaged in the passenger-car and motor-truck fields, depend upon the satisfaction their products render. Service is an integral part of their activities that cannot be long ignored. To maintain position in the highly reputable and prosperous way that it should be maintained, and will be maintained by those who shall survive through coming years, motor-vehicle builders and dealers must meet in a fair and square manner their responsibilities which are inextricably linked with the needs of their car-using customers. One of the first thoroughgoing reductions to practice in scientific and engineering progress should be in the maintenance of the millions of motor cars now in operation, not to speak of the many millions more to come. The longer the comprehensive solving of this service problem is deferred, the more arduous it will be to accomplish. The establishing as fully as possible of desirable conditions in the very complex and widely scattered field of automobile service requires long and thorough study by the best brains of the industry.

The Technical Sessions

At the Service Meeting of the Society held in Chicago on Jan. 31, much definite information was given and many pertinent data submitted in this connection by well qualified men who presented papers and took part in the discussion. Don T. Hastings, who is vice-president in charge of service for Hupmobiles in Detroit territory, described in a clear manner the system that he and his associates have established, and related convincingly his views on the so-called flat-rate method of conducting a service-station. J. F. Page, general manager of service of the Packard Motor Car Co. in Chicago, suggested various things that he felt a motor-car builder should do in the way of cooperating with dealers. O. C. Funderburk, who is a distributor of Lincoln and of Ford cars in Boston, prepared for the meeting a paper outlining the fundamental considerations according to which he believes a service-station should be organized, and narrated in considerable detail salient features of the maintenance service which he has been instrumental in providing for the cars mentioned. A. H. Packer, of the *Motor Age* staff, described graphically the many essentially important benefits to be had through suitable standardization of electrical equipment such as generators and motors of automobiles, with special reference to maintenance. The papers presented by Mr. Hastings and by Mr. Page were included in the February issue of THE JOURNAL. Mr. Funderburk's paper, as well as that of Mr. Packer, is included in this issue.

The Flat-Rate System

Mr. Hastings said that the men working in his shop under the flat-rate system earn about 25 per cent more than they would earn if employed by the day or according to the customary hour-rate. He believed that perhaps the chief merit

COMING NATIONAL MEETINGS

AUTOMOTIVE TRANSPORTATION MEETING
Cleveland—April 26-28

SUMMER MEETING
Spring Lake, N. J.—June 19-23

PRODUCTION MEETING
Cleveland—Oct. 25-26

ANNUAL DINNER
New York City—January, 1924

ANNUAL MEETING
Detroit—January, 1924

of the flat-rate system is its appeal to the car-owner in that he knows what a given job will cost him before work on it is started; the rates being low enough so that there is no adverse criticism of the amounts charged. The customer is informed in advance of what the charge for new parts and material will be, if it can be foretold to what extent these will be necessary in the handling of the job. In reply to the view that was expressed at the meeting that the flat-rate system cannot be entirely fair to all car-owners, Mr. Hastings said that the time necessary to take on jobs does not vary 25 per cent in amount from minimum and maximum times except in extreme cases and that the general result is that, whereas one customer will not always gain as much as another in the reduction of a charge, all of the customers gain in this respect owing to the general speeding-up of the work going through the shop. He asserted that fairness is the fundamental basis of all service that is good. The customer at his option concurs as to the fairness of a charge before the work is started. Mr. Hastings was of the opinion that a car-user would in the long run pay more for repair work if he had it done on the basis of time-unit charging. Secretary Cobleigh, of the Service Committee of the National Automobile Chamber of Commerce, said that the average cost of repairs is always lower in the flat-rate system than in the observance of the older basis. He felt that even the careless car-owner gets his maintenance work done at a lower price when the flat-rate method of charging for service is followed.

Scope and Magnitude of Maintenance

Clyde Jennings, editor of *Motor Age*, presided at the afternoon session of the meeting. He pointed out that maintenance, which term he prefers to service in connection with the matters under discussion, is a larger field of endeavor than direct automobile production, from the standpoint of the number of people concerned and also with regard to the amount of money involved in the annual turnover. About $2,000,000,000 worth of new cars was sold at retail during the year 1922. The expenditure relating to maintenance, purchase of parts and labor was about $5,000,000,000 during the same period. He stated emphatically that the big thing before the automotive industry is service, this being a growing business. Many automotive engineers are devoting their entire time to service problems, working out some of the almost unlimited details involved. He said that the flat-rate system is of great value in "selling" maintenance, which must be made an easily understandable as well as properly conducted thing.

Mr. Funderburk, in his paper on the servicing of Lincoln and Ford cars, gave detailed information with regard to various tools that had been devised for the maintenance equipment. The members who reside near or shall have occasion to visit Boston are advised to call upon Mr. Funderburk, as he has generously expressed a willingness to show them through the shops of his company. Mr. Hastings also will welcome any of the members who wish to inspect his service-plant in Detroit.

J. W. Lord, service manager for Pierce-Arrow cars in New York City, felt that it would be better for the vehicle distributors to provide maintenance of electrical equipment themselves instead of having their customers depend for this upon the different manufacturers of the electrical equipment furnished on their cars.

The discussion at the two technical sessions of the meeting was very interesting and distinctly valuable. There was a keen appreciation of the necessity for further study and discussion of the vital principles at issue in the conduct of satisfactory service. The time to take intelligent action is in advance of the coming of obstacles that may be nearly insurmountable, and there is good prospect that those engaged in the design, production and servicing of automotive vehicles will do more and better work on the many great problems of car maintenance before the industry. As indicated herein, several excellent texts were presented at the Chicago Service Meeting. It is earnestly recommended that the members give close attention to them.

The dinner held at the Congress Hotel on the evening of Jan. 31 was a decidedly enjoyable and inspiring occasion. Major Godfrey H. Atkin did the toastmastering in a very acceptable manner. Edward S. Jordan, president of the Jordan Motor Car Co., was the principal speaker of the evening.

Address by Edward S. Jordan

The members were very deeply interested in what Mr. Jordan had to say in speaking to the subject, The Greatest Business in the World.

Mr. Jordan said that to secure accurate information on the idiosyncrasies of various prominent members of the Society he had visited the geographical center of the automobile industry, namely, the barber-shop of the Detroit Athletic Club; the said geographical center having been formerly the bar of the Hotel Pontchartrain in Detroit. After paying his compliments to the various colonels associated with the Society, he expressed the opinion that nevertheless the industry is as sound as a nut.

The speaker presented the view that, judging from the current volume of production, a total of 3,000,000 new automobiles will be made in this country this year. He pointed to the fact that if 2,500,000 automobiles are built this year it is reasonable to suppose that in addition at least 1,000,000 used cars will have to be sold during the same period.

Mr. Jordan made it clear that the fundamental thing behind success in those things on which transportation is based, is service. Essentials of the automobile business are men, money, good merchandise and a market. Of these, men are the most important, and they must have the spirit to serve well; a knowledge of the business; and know what they are doing, where they are going, and what they are trying to accomplish. They must recognize what service means, have courage to stop watching the man across the street and to analyze their own business and possess basic honesty.

In the course of his address, Mr. Jordan reiterated what he said at a meeting of the Detroit Section of the Society some months ago, namely, that the determining factor in the automobile business is not original list-price but the second-hand price; stating that millions of car-owners would take delivery of new automobiles promptly if the dealers in their localities could allow them what they consider enough for their present machines. That is the limiting factor of the business. The production end of the industry has been developed fairly well, and the factory capacity is considerably beyond that needed to meet the current demand for cars. The merchandising stage has been reached, and we are approaching the fundamental, vital stage, that of service. Mr. Jordan continued:

> When a man gets tired of walking, and of riding a bicycle or a motorcycle or in a street-car, he buys a Ford. It is a matter of social progress from that time. After he buys a Ford he saves some money, stays home nights and is under the influence of his wife. Then he gets a Dodge. He still is making social progress. Later, some Sunday morning, his wife notices a neighbor with a car that is always coming along with the cut-out open; this cut-out says, "I am coming socially." It is the Buick coming up the hill. As the Buick passes over the hill she decides that she ought to have a car in that field. They have arrived at the deadline of big-volume production, with the possible exception of the Cadillac.
>
> Leaving the Buick, we reach what we call the kissable buyers. The daughter comes home from college and the five family factors begin to operate: Father, who thinks in terms of economy; mother, who thinks of her children's opportunity; the daughter, who thinks of social prestige and a happy marriage; the boy who thinks travel, speed and pep. Then, there is a pet in every family; a horse, a dog, an automobile, a bank account, or a victrola or some other pride-possession. We have got to sell them on the possession of an automobile and what it can do for them.
>
> Those four human factors can function only through

their five senses; sight, which is color, the daughter wants the house painted a different color when she gets home from college; feeling, she wants a steam-heating system; taste, she wants a cook in the kitchen; atmosphere, she wants a rug and a picture; and hearing, she wants a victrola, and she doesn't want any noise in the transmission.

THE SECRET OF SUCCESS

I will tell you what I believe is the secret of success in any business. If you have an engineer who has brains and common sense and does not think he is a better engineer than ever lived before on the face of the earth, he will just try day after day, not to revolutionize the industry, but to take what men of intelligence have done before and build on that, and keep on improving and improving and gradually raising his curve of effectiveness; if your purchasing agent has brains enough and is well supported, he will go on buying with the idea of improving the service rendered by the product for which he is buying materials, and his curve naturally rises; and it follows naturally that the production curve rises, the selling curve rises, the cost curve goes down, the cost-of-service curve goes down, the profit curve gradually rises and there is more money coming into the accounting department than is going out, and you are a success in business, and get an invitation to address the Society of Automotive Engineers. There is nothing magical about it. It is just a matter of deciding each day what you know to be right, rejecting what you know to be wrong.

How are we to find out what to do in our business? There is only one way. If you are an engineer, do not ask the sales manager. He doesn't know; he thinks he knows. Don't ask the production man. Don't ask the fellow across the street. Ask the fellow we are all working for, the owner of the automobile. He will tell you all about what to do to your automobile; he knows all about it. If you see enough of him and get in touch with him, you do not need to know what the sales manager thinks because you know what the man wants.

One question that is very often asked is, Who will survive? It does not make any difference to me how many companies there are in the business today. It does not make any difference to me how many cars they built last year. The question is, What kind of service have they built into their automobiles? How much will they be worth 1, 2 and 3 years from now? Those who serve best will survive. If you are engineering honestly, purchasing intelligently, producing carefully, inspecting right, rendering the greatest possible service, selling according to a definite policy and never changing, not being guided by the man across the street, not simply trying to out-produce or out-sell or out-engineer some fellow around the corner, but going on day after day building a little better, pricing your product as best you can, from the standpoint of your facilities and overhead expense and rendering a higher degree of service day by day, trying honestly and intelligently to render more service and deliver a better dollar's worth of transportation to the man who drives your automobile, that is the best you can do, and that will keep you in the automobile industry. There are only a few experts in any line of business. There are only a few good salesmen. But I can tell any young fellow in this Country how to make a success in selling automobiles or anything else. The first thing he has to do, whether he is an engineer, a purchasing agent or a production man, is to make every man around him feel that he is sincerely trying to render a service to somebody else. Once he makes up his mind that he will do that; sets out definitely to do it, keeping in mind the other fellow and the service that he is rendering to him; and puts his heart and his soul into it, you just can't stop him.

SKIRMISH OF DESIGNERS AND SERVICE-MEN

Inaugural Joint Meeting of Metropolitan Section and Service Association

E. J. Rabidoux, president of the Automotive Service Association of New York, and W. E. Kemp, chairman of the Metropolitan Section of the Society, were umpires at the joint meeting of the two organizations held at the Automobile Club of America last month. Lee Eastman, president of the Packard Motor Car Co. of New York, and of the Automobile Merchants' Association of New York, was referee. The session, which was largely attended by service managers of automobile distributors doing business in metropolitan territory, was devoted to service-station problems. It was the first meeting of the kind that has been held and constituted an excellent beginning of more intimate contact between and increased effectiveness of designers of motor vehicles and service-men. Throughout the discussion there was a marked tendency to distinguish between engineers and service-men with regard to their technical qualifications. It is a fact, however, that the two fields are not mutually exclusive in this respect as there is plenty of room for engineering training and ability on the part of service-men. Mr. Eastman paid very generous tribute to the designing engineers for their accomplishments in recent years and spoke of the service-men as their younger brothers. He said, moreover, that the engineering, business and service elements of the automotive industry should dovetail closely. He warned the service-men not to tell everything they knew at this meeting.

J. W. Lord, service manager of Harrolds Motor Car Co., which handles the Pierce-Arrow product in New York City, presented a paper on the subject, Does Factory Organization Give Full Consideration to Service-Station Problems? He pointed to the fact that the public is demanding better, cheaper and more prompt repairs and that there is increasing realization that maintenance has not received the close study which has been given to automobiles from the production and the performance standpoints. He took as a theme that the manufacturer who can sell the most miles per gallon of reliable truck transportation is the one to whom the public will come with its transportation problems. There are fundamental service problems that must be solved while the vehicles are being designed and produced. There is a feeling in the field that the engineers in the factories are inclined to be arrogant and obstinate. Mr. Lord felt that this condition will be obviated as the factory engineer takes more interest in service problems and becomes more closely in contact with service and maintenance. He is of the opinion that the flat-rate service is the most satisfactory method of selling maintenance and that it will become general; also that the flat labor-rate plus the cost of material is liable to make the final charge to the customer greater. The maintenance of the flat-rate service depends on the possibility of doing the same job on any car or truck of given make and model in approximately the same time. With regard to the use of private parts, Mr. Lord pointed to the significant fact that the makers of these parts are doing a flourishing and growing business, concluding that it is not clear that their products are not giving fair service.

Past-President Bachman, who had prepared a paper in connection with that of Mr. Lord, said that in cases where the designing engineer can be criticised justly for arrogance the service-man is frequently reprehensible for the impetuosity with which he makes and supports assumptions. He explained that it is an arduous job for a designer to make and maintain personal contact with a multitude of dealers.

Mr. Bachman argued that undue merit has been claimed for flat-rate system, stating that it is not the only method which can be made satisfactory to the car user. To make the price for work acceptable it must appear in the buyer's mind to be fair and be based on an accurate method of determining the cost. There are flat-rate prices for service re-

(*Concluded on p.* 317)

Research Topics and Suggestions

THE Research Department plans to present under this heading each month a topic that is pertinent to the general field of automotive research, and is either of special interest to some group of the Society membership or related to some particularly urgent problem of the industry. Since the object of the department is to act as a clearing-house for research information, we shall be pleased to receive the comments of members regarding the topics so presented, and their suggestions as to what might be of interest in this connection.

FUEL WASTE, ITS CAUSES AND REMEDIES

THE Society of Automotive Engineers recently was requested to have representatives testify before the United States Senate Committee on Manufactures regarding the part that the Society is taking in the elimination of motor-fuel waste. The accompanying statement was prepared by members of the Research Committee in conference with the officers of the Society. This statement, as well as the oral testimony of two representatives of the Society, was made a part of the minutes of the Committee on Manufactures in connection with its investigation of the price of gasoline.

THE SOCIETY'S INTEREST IN ECONOMY

The Society of Automotive Engineers has a membership of about 5000, including practically all of the engineers engaged in the design and production of the various forms of power units using gasoline as a fuel. This includes passenger and commercial vehicles, aircraft, tractors, motorboats and stationary power units. It is purely an engineering and technical society, organized for the advancement of engineering knowledge in the lines above mentioned by cooperative discussion and research.

The Society is interested in the elimination of all forms of waste, including that of gasoline, the conservation of which is considered to be of particular importance. Gasoline has become a most important fuel because it has enabled us to place in the hands of almost everyone a prime-mover in small units capable of reasonably satisfactory operation even by the most unintelligent. Due to the lack of technical skill of the great majority of the operators, the tendency toward waste of fuel in operation is greatly increased. Changes in design of automotive apparatus except in the direction of more automatically correct operation does not offer as fruitful a field for improvement so far as economy is concerned, as does the education of the user along the lines of more intelligent operation of the vehicle.

USE AND WASTE OF OIL

About 20,000,000,000 gal. of crude petroleum are used annually in this Country in producing the more than 5,000,000,000 gal. of gasoline, of which some 4,000,000,000 gal. is used by automotive vehicles for purposes of transportation. Of these vehicles, only a very small proportion are operated under centralized supervision that promotes the maximum economy of operation.

In the production and distribution of motor-fuel from crude petroleum, and in the use of this fuel, there is bound to be some waste as there is in all other commercial activities. Part of this waste is preventable by means already at our disposal. Other forms of waste, where prevention is probably possible, are the subject of concentrated study at the present time. The losses that occur in the manufacture and distribution of gasoline are not directly within the province of the automotive industry, and we will therefore confine ourselves in this statement to the preventable waste in the actual use of fuel.

COST AND QUALITY OF MOTOR-FUEL

The quality of gasoline, which partly determines its cost and the economy with which it is used, evidently has a considerable bearing on the ability of the user to operate his vehicle with maximum efficiency. This feature of fuel production vitally concerns the automotive industry and has been the subject of research and development since 1912, under the auspices of the Society of Automotive Engineers and, further, of cooperative research under the joint direction of the engineers of the automotive industry, and of the petroleum industry as represented in the American Petroleum Institute.

Gasoline for motor-fuel has come to be the highest-priced quantity-product of petroleum, except lubricating oil, and the motor vehicle is the largest single user of both products. Neither of them has any competitor at anything like the present price, and petroleum, the source of both, exists only in quantities that may be exhausted in a comparatively short time. Hence the elimination of waste is as important for conservation as for the maintenance of a minimum fuel-cost. Unfortunately, low cost and conservation do not always go together. Insofar as the user is responsible for the elimination of waste, a higher cost offers more incentive for economy.

FUEL IN THE ENGINE

Essentially, the automobile engine consists of a number of cylinders in which a mixture of gasoline vapor and air is burned to produce pressure that is transmitted to moving pistons and applied as power to the crankshaft and thence to the wheels. The fuel must be vaporized and intimately mixed with air in the correct proportions at the time that ignition takes place to allow of efficient combustion.

The carbureter and the intake-manifold are designed to perform the function of mixing the correct amount of fuel with the air, and to distribute the resulting mixture to the cylinders. The mixing of the fuel and the air begins in the carbureter and, after continuing during the passage through the manifold, is completed in the cylinder. With the low-volatility gasoline now being supplied for motor-fuel, a considerable amount of heat is necessary for the proper mixing of the air and the fuel. This heating may be applied in different ways; by maintaining the cylinders at a proper temperature, or by supplying heat to the carbureter or the manifold or both. If the correct proportion of fuel to air is not used, or if the mixture is not distributed uniformly to the different cylinders, some fuel will be wasted.

As a matter of fact, it begins to appear that the adoption of means for maintaining the engine at a uniform operating temperature under all climatic conditions will go a long way to improve economy. Experience indicates that this temperature should be fairly high to obtain the most efficient operating results. The economical use of fuel is thus promoted not only by the better utilization of the fuel itself, but also by maintaining the engine lubrication at its maximum efficiency, producing the lowest engine friction. It has been proved that temperatures provided by holding the cooling water at or near the boiling-point are not too high. In addition, for use in cold climates, it may prove

desirable to provide extra heat at the carbureter and the manifold, especially at the time of starting, when the engine is cold.

Mixture Adjustment and Fuel Waste

A mixture may be too rich in fuel and still produce power, without any obvious bad effects to warn the operator that he is wasting fuel. In fact, double the necessary amount of fuel can be used in this way without the user being aware of it. Over-rich mixtures are commonly used for reasons given below. Tests by the Bureau of Mines of 100 or more trucks and passenger cars picked out at random on a city street have shown that, in the average operation of trucks and passenger cars, 25 per cent of the fuel drawn into the engine passes out of the exhaust unburned.

The causes of waste of this kind are chargeable partly to the designer and partly to the user of the vehicle, or to the mechanic who attends to the adjustment. Practically all fuel-systems require adjustment to give the correct fuel-mixture. If these adjustments are not properly made, the waste of fuel may be 50 per cent, and probably the average loss in practice is at least 20 per cent. Owing to the large number of unintelligent and careless drivers who operate cars, it would be better if the carbureter setting and other adjustments could be made at the factory but, owing to variations in the fuel and in the weather conditions, this has not proved feasible up to date.

If the carbureter is constructed so that the correct mixture is not supplied under all driving conditions without continual hand-adjustment, or if the mixture between the fuel and the air is not sufficiently complete at the time of ignition, there will be a waste that no amount of care in adjustment can prevent. As to the question of a sufficiently intimate mixture, this involves the complete design of the powerplant, including the carbureter, manifold and engine, it being understood that the final mixture is produced by a violent agitation with the addition of heat. There is little doubt that one-half of the cars in use are deficient in design in the respects that make for a proper mixture of the fuel and the air before ignition, and that the fuel-consumption of these cars could be reduced at least 20 per cent by slight modifications in design and, in many cases, by simply replacing the parts that make up the fuel-system by others that are more efficient and already available.

Researches to Promote Economy

The causes of the excessive use of fuel have been under investigation by the Research Committee of this Society since 1919. A Report was published in 1920 to give the designers and service departments the latest information on the design of intake systems to secure economy of fuel. Although this report is only about two years old, much of the information given in it has been superseded by later developments. The same general subject is being investigated by the United States Bureau of Standards, which has already produced results making possible savings of millions of dollars worth of motor-fuel. Some of these savings are being realized in the operation of motor vehicles by the Post Office and other Government Departments.

Another direct source of fuel waste is the bad mechanical condition of many automobile and truck engines in service. Worn or improperly adjusted pistons and valves and ignition failures all waste fuel. Waste of this kind is a question of design and construction insofar as these bear on the proper functioning of the various parts, their durability and ease of repair. Its prevention is to a far greater extent in the hands of the various operators. It is obviously very difficult to predict the possible saving in this direction. All causes of mechanical friction, such as badly adjusted brakes and bearings and lack of oil, absorb power and waste fuel.

One of the main objects of the Society is the elimination of fuel waste by improvements in design, construction and methods of upkeep. Direct waste of fuel has received the most attention, as it represents the greatest preventable loss. Within the past 5 years, some 50 technical papers and reports have been published in The Journal of the Society on this subject alone. The main reason for this activity is the fact that commercial gasoline as sold to the consumer was becoming more and more difficult to use with economy. Gasoline is a mixture of different constituents having different degrees of volatility or ease of vaporization. Up to about 1912, commercial gasoline contained only the most volatile constituents and offered no difficulty in vaporizing for producing a satisfactory mixture for use in the simplest type of engine. With the increasing demand it became necessary for the producer to include heavier and less volatile constituents that require more heat for their vaporization and, as this process went on from 1912 to 1920, the utmost efforts of the designers were necessary to keep pace with the change in fuel and maintain reasonable economy.

Accomplishment of American Automotive Engineers

In fact, we believe that the American automotive engineer is even now in advance of all others in the technique of economical fuel-utilization. In dealing with the fuels of low volatility marketed is this Country he has learned much as to the behavior of fuels in the engine and has profited by this knowledge in the design of efficient vehicles. European cars average more miles to the gallon than American cars but, when reduced to a common basis of weight and reserve power, the American cars are superior in economy. Due to high fuel-cost and taxation, European design has tended to attempt to secure high mileages by a reduction of the weight and the reserve power. The demand of American car-users, partly due to the poor condition of roads, has called for the heavier weight and the greater reserve-power of average American cars.

In accomplishing this result the designer has had to overcome the practical difficulty of meeting the demand of the automobile user mentioned above. High power, which is only rarely used, and the ability to take steep grades and accelerate rapidly without changing gears, which is demanded by the public in passenger cars today, are incompatible with maximum fuel-economy. This high power, which is only occasionally used, introduces features of design that result in fuel waste and also encourages a carbureter adjustment that is wasteful since maximum power in any engine is never associated with minimum gasoline consumption. The amount of fuel used to obtain the above characteristics may be 50 per cent more than that which would be required were maximum mileage per gallon the chief consideration. Moreover, the desire for starting-off quickly at full power in cold weather before the engine has become heated tends toward a still further excessive use of fuel. The average driver appears to desire to have his fuel system adjusted to give the maximum power and a quick getaway in cold weather, perhaps because he does not know the penalty he is paying in fuel waste.

Responsibility of the Driver

To illustrate what this means, we would say that our best information indicates that a majority of 1-ton cars in the hands of average drivers actually cover not more than 16 miles per gal. of fuel. We are convinced that, if these same cars were more carefully designed and provided with a more satisfactory means for supplying the correct fuel-mixture, they would average under the same operating conditions 20 miles per

gal. instead of 16, and that a further improvement of at least 25 per cent would be possible through more careful operation by drivers.

The fuel waste in commercial vehicles seems to be even worse. Some fleets of commercial vehicles weighing about 4 tons including load average only 5 miles per gal. of fuel, while others of equal weight and in about the same service average 12 miles per gal., the differences being due partly to differences in design and equipment and partly to differences in the care with which the various adjustments are made and the operation of the vehicles is conducted.

It should be noted that the automotive industry as it exists in this Country is only about 10 years old. Not only have most of the engineers and manufacturers been trained in that brief period but the rapid expansion of the use of motor vehicles has introduced new and untrained drivers at the rate of about 1,000,000 per year. The production of vehicles to meet the demands of these untrained users has made the building of really economical units doubly difficult.

Effects of Fuel Volatility Investigated

Gasoline waste depends partly upon the quality or the volatility of the fuel used for the reason that the volatility affects its adaptability as a fuel for the engine consuming the greater part of this product. But the greater the quantity is of gasoline made from a barrel of crude oil, by any given process, the lower the volatility is. The best interests of the public, as well as of the automotive and oil industries, will plainly be served by obtaining a maximum amount of satisfactory fuel from each barrel of crude. To accomplish this, it is necessary to know how heavy a grade of gasoline can be used in average vehicles without disproportionately increasing the amount of fuel consumed, or the difficulty of operation. About a year ago the oil and the automotive industries determined to attempt to obtain an answer to this question by means of a joint research. Several refineries furnished special fuels for the purpose and 10 automobile companies undertook, each independently, an extensive research program, under the supervision of the Research Committee of this Society.

Some features of such a research could best be handled by an impartial third party who might be said to represent the public, and we have felt ourselves very fortunate in having in the Bureau of Standards an organization and equipment capable of taking up certain lines of this investigation and carrying them out in the most efficient manner. It was therefore decided to turn some of the most important questions over to the Bureau of Standards for determination and to aid the Bureau by the loan of materials and assistants from both the industries engaged in carrying out the work. This investigation at the Bureau of Standards has been in progress for less than a year and it is obvious that any final determination in a matter so important and complicated as the one under discussion could not be arrived at in that length of time. On the other hand, there are indications from observations made uptodate that a quality of gasoline may be used in automotive vehicles with a reasonable degree of satisfaction and economy, in summer at any rate, which will alone make possible an increase of some 30 per cent in the amount of gasoline that is producible from every barrel of crude oil.

Summary of Factors Affecting Economy

The several factors that promote fuel economy may be summarized briefly as follows:

(1) Universal adoption of means for maintaining the engine and the carbureter and intake system at the best operating temperature

(2) The adoption as rapidly as possible of carbureting devices that can be adjusted once for all by the maker to supply automatically a correct amount of fuel as completely atomized as possible for economical operation under all conditions

(3) An economically correct grade of gasoline supplied uniformly throughout the Country but suitably varied if possible to meet climatic conditions. Uniformity of fuel would go far to make possible the adoption of the more economical carbureting systems suggested above.

(4) Education of the user of motor vehicles to the advantages that will accrue to him through fuel economy. These advantages are in reality much greater than the saving in fuel cost. They include also less wear in the engine, less carbonization, less upkeep cost and freedom from other minor annoyances

(5) The gradual adoption of engines using higher compression-ratios, with resulting higher fuel-economy. This can be accomplished only as improvements in design or in the quality of the fuel make higher pressures possible without engine knock, which at present limits the usable compression-pressures

(6) Servicing of automotive equipment to maintain it in satisfactory condition for economy of operation. This refers to the entire vehicle as well as to the engine, and present conditions can be improved by the education of the public and of the garage mechanic, and by improvements in the service facilities offered by the dealers

All of these factors, except perhaps the education of the general public, are receiving a continually increasing amount of study by the Society of Automotive Engineers and the manufacturers and we believe that much has already been accomplished in eliminating fuel waste. The necessity of meeting popular demands inconsistent with economy, and the difficulty of putting new developments into immediate production, have retarded this accomplishment. Even more important perhaps is the fact that the average vehicle now in use is a product of 2 or 3 years ago, not of today.

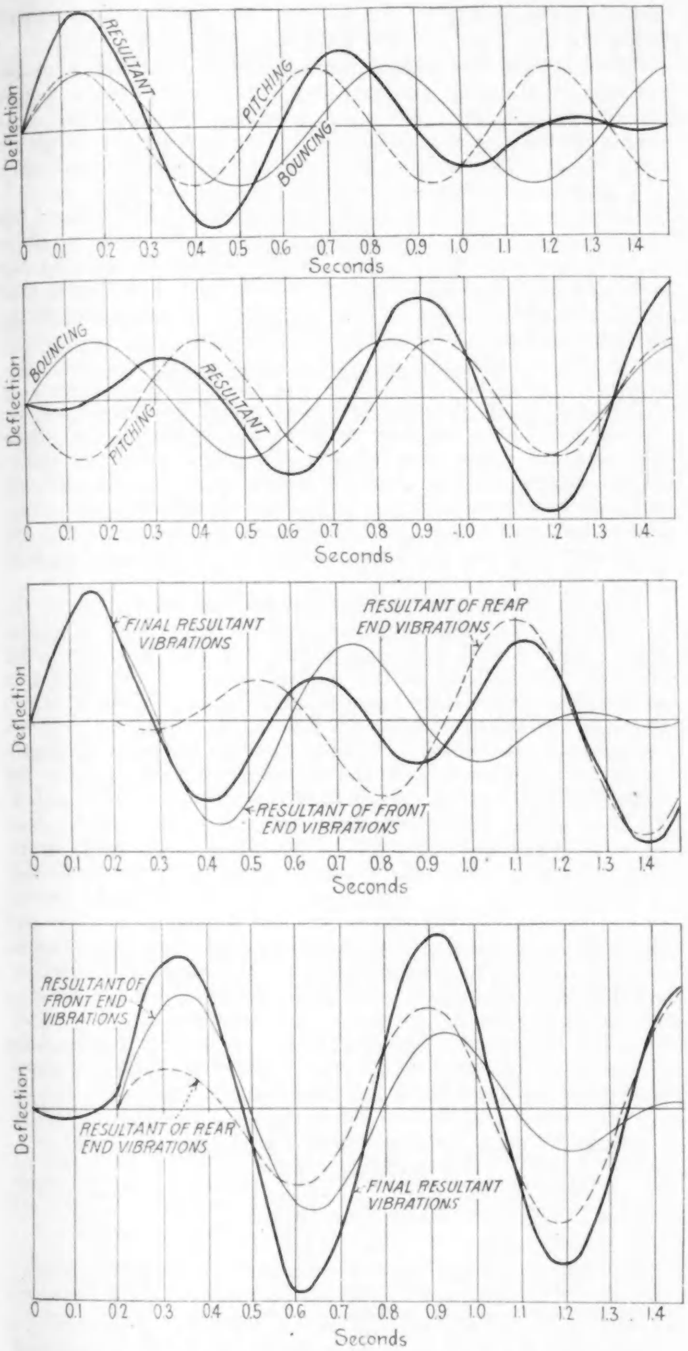
NOTES ON SPRING ACTION

It is a well-known fact that automobiles having apparently similar suspension systems are often widely different in springing qualities. Why this should be is likely to remain a mystery until we have at least the elements of a rational theory of spring action in automobiles. Although a general theory is lacking, the mechanics of spring-fitted vehicles has been studied by a number of investigators who have deduced a few theorems that point to certain vehicle constants as possible factors in the suspension problem. These factors are the periods of vibration, the axes of oscillations and the distribution of weight in the body.

Periods of Vibration

Akimoff in his paper entitled Remarks on the Dynamics of the Automobile[1] has shown that Lagrange's method of analysis leads to two distinct formulas for the periods of plunging and pitching respectively. Using the same method, we have generalized Akimoff's formulas to apply to an auto-

[1] See Transactions, vol. 12, part 1, p. 141.



Vibration of the Front End after the Front Wheel Has Hit an Obstruction
Vibration of the Rear End after the Front Wheel Has Hit an Obstruction
Resultant Vibration of Front End as Combined from the Individual Vibrations of Each End
Resultant Vibration of Rear End as Combined from the Individual Vibrations of Each End

FIG. 1—EXAMPLES OF THE SUPERPOSITION OF BOUNCING AND PITCHING VIBRATIONS

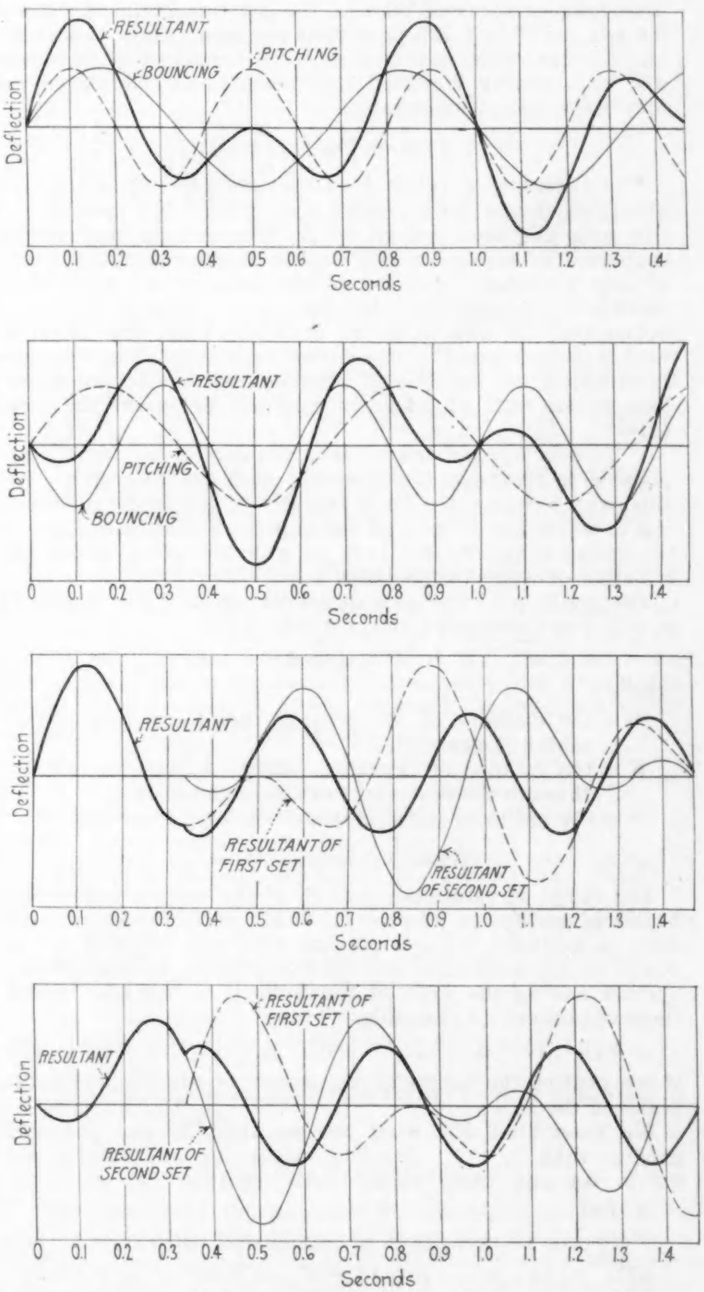
mobile in which the front and the rear springs are not the same and in which the center of gravity is not limited to a horizontal position half-way between the axles. We find that bouncing, or straight up-and-down vibration; pitching, or oscillation about a transverse horizontal axis; and rolling, or oscillation about a longitudinal horizontal axis, are all generally present simultaneously. The formulas for the periods of bouncing, pitching and rolling are

$$B = 2\pi\sqrt{([W/g] \times [1/(m+n)])} \qquad (1)$$
$$P = 2\pi\sqrt{([W/g] \times [k^2/(a^2m + b^2n)])} \qquad (2)$$
$$R = 2\pi\sqrt{([W/g] \times [abr/(2c^2[a^2m + b^2n])])} \qquad (3)$$

where

a = the horizontal distance of the center of gravity from the rear axle
b = the horizontal distance of the center of gravity from the front axle
c = the track
g = the acceleration due to gravity, 32.2 ft. per sec. per sec.
k = the radius of gyration about the axis of pitching
m = the constant for one rear spring
n = the constant for one front spring
r = the radius of gyration about the axis of rolling
W = the weight of the car body

By making $a = b = 1$ and $m = n = W/2\delta$, where δ is the



Vibration of the Front End after the Front Wheel Has Hit an Obstruction
Vibration of the Rear End after the Front Wheel Has Hit an Obstruction
Resultant Vibration of the Front End as Combined from the Individual Vibrations of Each End
Resultant Vibration of the Rear End as Combined from the Individual Vibrations of Each End

FIG. 2—ANOTHER EXAMPLE OF THE SUPERPOSITION OF BOUNCING AND PITCHING VIBRATIONS

initial deflection of the spring, our formulas reduce to those given by Akimoff in his paper.

$$B = 2\pi\sqrt{(\delta/g)}$$
$$P = 2\pi\sqrt{[(\delta/g) \times (K^2/l^2)]}$$

The ratio of the first two vibrations is

$$P/B = k\sqrt{[(m+n) \div (a^2m + b^2n)]} \qquad (4)$$

Since the location of the center of gravity and the radius of gyration are determined by the distribution of the weight, formula (4) suggests that, if the riding qualities are influenced by changes in this ratio, the designer has it in his power to select favorable values for these variables.

As an indication that ease and comfort in riding might be affected by even slight changes in period, we may cite the measurements of Broulhiet[2], who showed that the periods of European cars varied between the extreme limits of 0.8 and 0.5 sec., or 75 and 120 vibrations per min. Only two exceptionally fine-riding cars had as low a period as 75 vibrations and cars having a period approaching 120 vibrations per min. were almost unbearable.

Axis of Oscillation

The radius of gyration k in formula (4) implies an axis about which the body rotates to-and-fro. The position of this axis has been defined by A. Herdner[3] for any vehicle supported by springs on any number of axles carrying wheels of any diameter. Reduced to the case of the automobile, Herdner's theorem fixes the axis for pitching in the plane connecting the two axles, at distances from the axles inversely proportional to the spring constants. For example, if $m{:}n{::}1.0{:}1.5$ the axis of pitching will divide the wheelbase in the ratio of 0.4 to 0.6 and will be nearer the front axle.

Herdner's proof needs some revision to be strictly applicable to the type of suspension used on automobiles, but this cannot change the main features of his theorem according to which the position of the axis of oscillation is fixed by the spring constants and is in no way dependent on the distribution of weight in the body.

The position of the axis of oscillation and the radius of gyration are connected by the relation

$$k^2 = d^2 + K^2$$

where

- d = the distance of the axis of oscillation from the center of gravity
- K = the radius of gyration about a parallel axis through the center of gravity of the body
- k = the radius of gyration about the axis of oscillation

Weight Distribution

The range of values assumed by K for various automobile bodies is not known at present, and it is therefore not possible to evaluate (4). It may be profitable however to attempt an approximation and for this purpose we shall choose springs having the ratio of constants $m{:}n{::}1.0{:}1.5$. Under these conditions, (4) becomes

$$\sqrt{[2.5/(a^2 + 1.5b^2)]} \times \sqrt{[(K^2/l^2) + ([b/l] - 0.4)^2]} \qquad (5)$$

if we neglect the height of the center of gravity above the plane of the axles.

We know that K/l must be less than ½ and probably greater than $1/\sqrt{12}$. Possible values for automobiles are 0.3 to 0.4 and these values substituted in (5) yield the results given in Table 1 for different positions of the center of gravity.

TABLE 1—INFLUENCE OF THE CENTER OF GRAVITY

b/l	$\sqrt{[2.5/(a^2 + 1.5b^2)]}$	r^2/l^2	$K/l = 0.4$	$K/l = 0.3$
0.50	2.00	0.0100	0.826	0.634
0.55	1.96	0.0225	0.837	0.658
0.60	1.89	0.0400	0.846	0.683
0.65	1.82	0.0625	0.860	0.708

We conclude from these figures that the difference in the periods of plunging and pitching are probably large enough to affect seriously the resultant motion to which the occupants of the car are subjected, but that the body-designer's control over the ratio of the periods is slight, at least when the spring constants are fixed.

The presence of passengers decreases K/l but, unless the seats are equidistant from the center of gravity, which is usually not the case, r also changes; how this affects the value of $k^2 = r^2 + K^2$ cannot be predicted. This point may be worth while investigating because of its bearing on the designer's control over springing quality.

Superposition of Vibrations

The radius of gyration and the axis of oscillation are involved also in the relation between the amplitudes of vibration and the forces causing the vibration. Little is known of the numerical size of the forces transmitted through the rubber-tired wheels to the body, but fortunately, the force enters the expressions for both amplitudes, of bouncing and of pitching, in the same way, and this circumstance permits a determination of the ratio of the amplitudes.

If we have the ratio of the amplitudes, as well as of the periods, we can determine the type of the resultant oscillation. Figs. 1 and 2 illustrate this for the front and rear ends of the car-body in the simple case of a vehicle drawn as a trailer at constant speed along a smooth road on which there is one sharp obstruction placed perpendicularly across the path of the vehicle. In both figures, the ratio of amplitudes is taken as 1, and the bouncing vibrations as 9 per min.; the ratio of periods is taken as 0.8 in Fig. 1, and as 0.6 in Fig. 2. The heavy lines are the resultants obtained by adding the ordinates of the vibrations. In each figure, the two upper groups of curves show the resultant oscillation of the front and rear ends respectively of the body, caused by the impulsive force due to the front wheels passing over the obstruction, and the other two groups show the effect of superposing on the first two groups the additional bouncing and pitching vibrations caused by the rear wheels meeting the obstruction after an interval determined by the wheelbase and the speed. The figures are drawn for a wheelbase of 120 in. at a speed of 15 m.p.h. for Fig. 1 and of about 13 m.p.h. for Fig. 2 as may be taken from Table 2.

TABLE 2—TIME TO PASS OVER WHEELBASE LENGTH AT VARIOUS SPEEDS

Speed, M.P.H.	Speed, Ft. per Sec.	Time to Pass Over 120 In., Sec.
10	14.7	0.71
13	19.1	0.52
15	22.0	0.45
20	29.3	0.32

Note that the amplitude depends on the ratio of the speed to the wheelbase and that there are ranges of speed for the minimum and the maximum shock. An extension of this method to any type of road seems possible by utilizing the studies made by Liebowitz, Napier, Baillie and others on the behavior of a single rubber-tired wheel.

Conclusion

The fragmentary theory that is implied in the combined work of Akimoff, Herdner, Broulhiet and Nadal[4] proposes to attack the suspension problem from two angles

(1) By assigning a definite and important rôle to the weight-distribution constants of the body
(2) By studying the resultant curves obtained by superposing the harmonic motions due to bouncing, pitching and rolling

In this paper we have sketched only the barest outline of this program, in the hope that interest may be aroused in the experimental verification without which this germ of a theory of springing must remain a collection of academic theorems.

[2] See *Revue de l'Industrie Minerale*, vol. 1, part 2 p. 87.
[3] See *Revue Generale des Chemins de Fer et des Tramways*, vol. 28, No. 6, p. 379.
[4] See *Annales des Mines*, vol. 9, p. 413.

Current Standardization Work

DURING the last month only a few Division meetings were held because the majority of the subjects awaiting Standards Committee action have been assigned to Subdivisions that are preparing reports for consideration at the Division meetings that will be held during March and April. It has been found that only through the assignment of subjects to definite Subdivisions for the preparation of preliminary reports can the Division work be carried on most advantageously with respect to the time of the Division members necessary in attending the meetings and the expense incurred through such traveling and absence from their regular engineering work.

The Society letter-ballots on the adoption of the standards recommendations approved at the Standards Committee Meeting in January will be counted on March 12 and the data sheets containing the standards adopted by letter-ballot issued in the latter part of the month.

Paints, Varnishes and Enamels

The following Subdivision on Paints, Varnishes and Enamels has been appointed by Chairman G. E. Goddard of the Passenger-Car Body Division:

J. Warren Armitage	John L. Armitage & Co.
Henry A. Gardner	Paint Manufacturers' Association
J. O. Hasson	Sherwin-Williams Co.
C. D. Holley	Acme White Lead & Color Works
L. D. Pulsifer	Valentine & Co.
W. J. Schlinger	Flint Varnish & Color Works
C. C. Schumann	Pratt & Lambert

Passenger-Car Door Hinges

At one of the early meetings of the Passenger-Car Body Division the importance of standardizing certain types of door hinges was realized and E. G. Simpson, of the Fisher Body Corporation, was appointed a committee of one to formulate a tentative proposal for consideration.

Seven standard hinges have been recently proposed by Mr. Simpson for concealed and outside door-hinges of the following types:

Closed-Body Guide Hinge — Closed-Body Strap Hinge
Open-Body Short Guide-Hinge — Open-Body Long Guide-Hinge
Open-Body Concealed Hinge — Closed-Body Concealed Hinge
Malleable-Iron Strap-Hinge

The proposed standards have been based on present practice and are intended to meet the requirements of the majority of the companies. Comments thereon are being obtained from body builders.

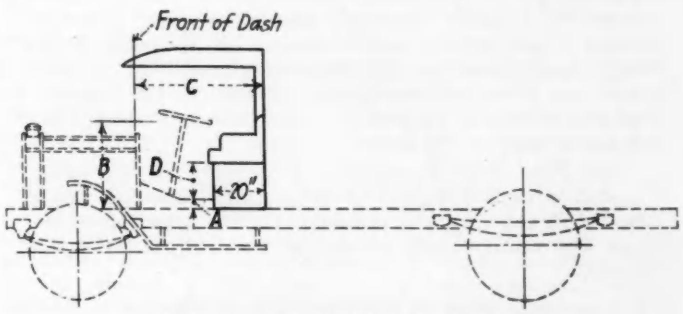
Motor-Truck Cabs

A meeting of the members of the Truck Division was held in the offices of the Society on Jan. 8, the day preceding the Standards Committee Meeting, to discuss the proposed S.A.E. Recommended Practice for Motor-Truck Cabs, that was printed in the December issue of THE JOURNAL, in conjunction with the comments thereon received from chassis and cab producers. It was decided to take no final Division action on the tentative recommendation, but to make what changes were deemed desirable and to submit the proposal to chassis and cab builders for comment with the understanding that final action would be taken at the next Division meeting to which cab builders would be invited to send representatives.

In view of the criticisms as to the widths specified, it was considered best to eliminate the width, as it is not necessary to obtain interchangeability of cabs in chassis. It was thought that it would be desirable to have a separate classification for speed-wagon cabs. As the Division members are not in the position to recommend the mounting dimensions, recommendations will be obtained from the cab builders as to desirable practice.

The dimension specified for the distance from the chassis to the windshield lower edge was changed to 36 in. for both sizes of cab, but it was felt that this dimension should be carefully considered by the cab builders before final approval.

The tentative Division recommendation as finally revised is given in the accompanying illustration.



PROPOSED MOTOR-TRUCK CAB DIMENSIONS

Truck Capacity, tons	A	B[1] Min.	C	D Variable
Under 2[a]				
2 to 3	3½	36	46	15½±1
Over 3	3½	36	46	15½±1

[1] Dimension B is from the top of the chassis frame to the lower edge of the windshield.
[a] This classification covers speed-wagons for which cab dimensions are to be standardized if feasible.

Passenger-Car Front-Wheel Hubs

Detailed dimensions for passenger-car front-wheel wood hubs were decided upon tentatively at a meeting of the Axle and Wheels Division in Chicago on Jan. 30. The dimensions, which are given in the accompanying table, are intended to constitute an extension of the recommendation approved by the Standards Committee on Jan. 9.

PASSENGER-CAR FRONT-WHEEL WOOD HUBS

Hub Size	Outside Diameter of Hub	Distance Between Flanges	Flange Diameter	Flange Fillet-Radius	Bolt-Circle Diameter	No. of Bolts	Bolt Size	Hub-Cap Thread
R0	2.1830 2.1860	1¼	6	⅜	5	6	⅜	2⅛-24
R1	3.0625 3.0655	1¼	7	¼	5¾	12	7/16	2 9/16-16
R2	3.5000 3.5030	1⅜	7¼	¼	6	12	7/16	2 9/16-16
R3	3.6875 3.6905	1½	7⅝	⅜	6¼	12	7/16	3 -16
R4	3.8125 3.8155	1¾	8	⅜	6¼	12	7/16	3⅜-16

Note: The data in the table apply to wheels with wood or steel felloes, that is to all wheels having wood hubs.

Radiator Nomenclature

The meeting of the Radiator Division, held on Jan. 29 in the rooms of the Old Colony Club at the Hotel LaSalle in Chicago, was attended by J. D. Harris, McCord Mfg. Co., Inc., chairman of the Division; H. B. Knap, Packard Motor Car Co.; Charles Oppe, G & O Mfg. Co.; Fred. M. Young, Perfex Radiator Co.; and Standards Manager R. S. Burnett.

In connection with the nomenclature of radiator cores, it was felt that the term "honeycomb" should not be used because it is inadequately descriptive. It is a trade term that is frequently applied to several types of radiator.

Chairman Harris presented four definitions that he had based on those suggested to the Division by Herbert Chase,

that were printed on p. 127 of the January issue of THE JOURNAL. After carefully studying the definitions proposed, it was decided to recommend the addition of the following definitions, as "Group 3—Types of Radiator Core," to the S.A.E. Standard for Automobile Nomenclature, page K5 of the S.A.E. HANDBOOK.

Group 3—Types of Radiator Core

Individual Fin-and-Tube Type.—A number of tubes of any cross-sectional form to each of which are attached gills or fins of circular, square or other shape, each tube and its fin or fins forming a separate unit.

Continuous Fin-and-Tube Type.—A number of tubes of any cross-sectional form assembled and joined together by fins or plates.

Ribbon Cellular Type.—A number of water passages formed by joining metal ribbons at the edges, the water-passage walls usually being crimped and grouped to form a cellular structure. Parts of the cellular structure may be formed by flat or crimped ribbon that is not a part of the water passage.

Air-Tube Cellular Type.—A number of air-tubes nested in such a way as to form water passages, being sealed at the ends of the tubes. In this type the water can flow transversely as well as vertically around the tubes.

The present radiator nomenclature in the S.A.E. HANDBOOK was revised to include the terms used in connection with the S.A.E. Standard for Radiators, p. A26 of the S.A.E. HANDBOOK, so as to have the nomenclature complete, each type of radiator being covered separately as follows:

Group 2—Radiators

Shell Type

Radiator upper tank
Radiator filler neck
Radiator filler cap
Radiator inlet fitting
Radiator tie-rod fitting
Radiator overflow tube
Radiator lower tank
Radiator outlet fitting
Radiator drain-cock
Radiator anchor stud or bolt
Radiator anchor stud or bolt plate
Radiator side bolting-member
Radiator shell
Radiator supports
Radiator hinge-rod fitting
Radiator hood-ledge liner

Cast Type

Radiator upper tank
Radiator filler cap
Radiator inlet fitting
Radiator tie-rod fitting
Radiator overflow tube
Radiator lower tank
Radiator outlet fitting
Radiator drain-cock
Radiator anchor stud or bolt
Radiator anchor stud or bolt plate
Radiator sides
Radiator clamping strips
Radiator header gasket
Radiator inlet gasket
Radiator outlet gasket
Radiator hinge-rod fitting
Radiator hood-ledge liner

SHEET STEEL

At the joint meeting of the Society's, the American Society for Testing Materials and the American Society for Steel Treating Sheet Steel Committees on Jan. 8, 1923, a Committee on Testing of Sheet and Strip Steels was appointed consisting of J. M. Watson, chairman, Hupp Motor Car Co.; C. N. Dawe, Studebaker Corporation of America; F. E. McCleary, Dodge Bros.; Jack Dailey, General Motors Corporation; L. A. Danse, Cadillac Motor Car Co.; and E. W. Upham, Maxwell Motor Car Co.

The Committee was given full power to fix the methods of testing and to obtain help from men not on the Committee. All tests are to be made in the manner prescribed by the Committee, which will send monthly reports on the work to the Standards Department of the Society for distribution among the Subdivision members. As all of the members of the testing committee are located in Detroit, it is felt that rapid progress can be made.

STEEL FELLOES FOR WOOD WHEELS

Letters proposing the standardization of the tenon-holes in steel felloes for wood wheels were discussed at the January meeting of the Axle and Wheels Division. It was argued that while there is practically a standard among the wheel manufacturers at the present time, a published standard would be helpful. The dimensions given in the accompanying table were approved tentatively for adoption as S.A.E. Recommended Practice.

DIMENSIONS OF TENON-HOLES FOR STEEL FELLOES

Pneumatic-Tire Size, In.	Spoke Size, In.	Diameter of Tenon-Hole, in.
3½-4	1¼	½
4	1⅜	⅝
4½	1½	⅝
5	1¾	¾

As "giant" pneumatic tires are not used on steel felloes, it was not felt necessary to include tire sizes above 5 in.

TIRE CLEARANCES

A suggestion of the American Chain Co. that the clearance between tires and fenders be standardized has been referred to the members of the Passenger Car Division for study.

In making this suggstion, J. R. Rayburn, of the American Chain Co., stated that

> It would seem of prime importance to provide a minimum clearance behind and ahead of the tires in a horizontal direction, preferably 3 in. The vertical clearance above the tires depends upon the extent of the spring action.
>
> We have found fender braces over tires free to contact with the tire on extreme spring compression. When this happens with chains attached, either the chains or the fender bracket must fail.

TOOL STEEL

Carbon tool-steel specifications have been tentatively approved by the Sub-Sub-Committee of Committee XIV of Committee A-1 of the American Society for Testing Materials. Copies of these specifications, which cover six classes of carbon tool-steel as determined by the chemical compositions, have been sent to the members of the Iron and Steel Division for comment.

The specifications cover the purposes for which the classes are frequently used; process of manufacture, crucible or electric-furnace; annealing; chemical composition; methods of analysis; permissible variations in dimensions; finish; marking and inspection and rejection.

SOCIETY MEETINGS

(*Concluded from p. 309*)

pairs of the most ordinary character which are obviously not justified. Much value lies in the flat-rate system in that it necessitates careful analysis of operations. Outside of the variation in labor and time that may result from the difference in individual conditions on the same class of job there is the more serious matter of variation in the amount of material required to do a first-class job under different conditions. Mr. Bachman felt that these variations cannot be properly provided for in the flat-rate system and that an overcharge in some cases and an undercharge in others are inevitable. One of the most interesting statements Mr. Bachman made was that there has been little or no demand for economical automobile transportation as opposed to cheap automobiles, and that it is probable that a product based on the former demand would be a failure. He said, however, that there is no doubt that shortly there will be a public demand for economy in automobile operation, which will be made possible by numerous factors, including highway development and general distribution of repair facilities.

Past-President Vincent contributed to the discussion of the papers mentioned above. He expressed doubt whether the averaging of repair costs as between cars that are well taken care of and those that are neglected is worse from the owner's standpoint than the fact that on a time and material basis the owner who is lucky enough to draw the fastest man in the service-station has an advantage. In addition, the man who takes care of his car will not need to have repair work done so often. Vehicles are designed to give good all-round results in territories varying greatly as to road and weather conditions. Mr. Vincent felt that the flat-rate system of service is fair, more businesslike and conducive to efficiency in the relations between the service-station and the vehicle owner. He said further that service-field suggestions, properly analyzed and checked, have resulted in refinement of car models.

O. E. Hunt, chief engineer of the Chevrolet Motor Co., concurred in the view that the average factory engineering organization is not closely enough in touch with service problems. He said that car builders will succeed in the proportion that they convince their customers that they are giving comfortable and dependable transportation at a less cost than their competitors are giving it.

A. J. Scaife, of the White Motor Co., expressed the opinion that it is difficult to get a large engineering organization aroused to the necessity of giving due consideration to complaints as to failure in service. He spoke of the merit of the car builder having representatives in personal contact with dealers, fleet owners and individual customers, as this results in bringing the customer's viewpoint directly to the attention of the engineering staff.

R. E. Fielder, chief engineer of the Fifth Avenue Coach Co., specified the fundamental requirements in the procedure of the operating engineer as being accessibility, simplicity, independent unit-construction, light-weight units that are easily handled, elimination of surplus refinements, fool-proof and accessible adjustments, and lubrication devices that are accessible and have adequate storage capacity. He believed that the time is near at hand when the operating engineer will determine which is the best type of vehicle to purchase.

C. B. Veal was of the opinion that the whole problem discussed resolves itself almost entirely into one of management and not of a difference of opinion between the designing engineers and the service-men. James Florida, of the Packard Motor Car Co. of New York City, said that in his opinion the flat-rate system has come to stay, as it not only increases efficiency in repairing cars but assists the owner in reducing his maintenance cost. Ralph Rognon, who conducts a large independent service-station in New York City, made a plea for planning development in service. He said much could be done along the lines of the standardization work of the Society. Past-President Manly made the point that the fundamentals of service are integrity and efficiency, neither one of which is worth much without the other; combined they will be effective in a flat-rate or any other system. Service Manager Trend, of the Maxwell-Chalmers Co., said that some factory service-departments constitute too great a barrier between the service-men and the designing engineers. Azel Ames, of the Advisory Board of the Metropolitan Division of the American Automobile Association, offered on behalf of car-owners cooperation in the solving of service problems.

Views were advanced by various speakers to the effect that some service-departments receive no cooperation from the factory engineers; that the latter do not visit the former even when they have a chance to do so; that no two jobs involve the same amount of work in the shop, and contrariwise that there is very little difference in the amount of time consumed as between different jobs. One service-man said that in operating, by giving the customer estimates as to the minimum and the maximum expense, only 7 out of 700 customers complained of overcharges. Another speaker said that in 18,000 operations the average time consumed was 36 min. for each.

In closing the session, Chairman Eastman said that he favored the flat-rate system but that he felt the public will have to be convinced of its merit; that is, made to understand the premises and conditions on which it is based.

NEW ENGLAND TO DISCUSS ECONOMICS

Harry Tipper, whose opinions on merchandising and the economic phases of the automotive industry are respected highly, will address the New England Section at the Engi-

Schedule of Sections Meetings

MARCH

2—Detroit Section—Painting Practice and Problems from the Chemist's Viewpoint—L. Valentine Pulsifer.
2—Washington Section—Engineering from the Service-Man's Viewpoint
7—Minneapolis Section—Development of the Modern Airplane—Charles Boehnlein
15—Metropolitan Section—Possibilities in the Development of the Trolley Bus—William P. Kennedy
16—Buffalo Section—Impressions of the New York City and Chicago Automobile Shows—J. Edward Schipper
16—Cleveland Section—The Value of the Consulting Engineer to the Automotive Industry—James A. Guthrie
16—New England Section—Economic Phases of the Automotive Industry—Harry Tipper
23—Mid-West Section—Road Lighting—F. H. Ford

neers' Club in Boston, Friday evening, March 16. This meeting occurs during the week of the Boston Automobile Show. It has been the custom of the Section to devote its meetings during show time to the commercial rather than the engineering problems of the industry. Mr. Tipper's talk will be followed by a showing of the North East Electric Co.'s latest animated pictures of starting, lighting and ignition apparatus. An informal dinner will precede the meeting at 6:30 p. m.

TWO MEETINGS ON LUBRICATION

W. F. Parish, lubrication engineer, addressed the Indiana Section on the evening of Feb. 15. His paper presented recommendations and experience relating to the Practical Application of Lubricants. Extremely cold weather affected the meeting attendance but those who defied the low temperatures enjoyed the paper very much. George Weidely, Lon R. Smith, Charles Trask and O. C. Berry took an active part in the discussion. Plans for the March meeting of the Section had not been completed definitely at the time of going to press.

A. Ludlow Clayden addressed the Pennsylvania Section on Feb. 20, presenting in an interesting manner some of the fundamentals of lubrication. The Pennsylvania Section will hold no meeting during March.

RECENT ADVANCES IN AERONAUTICS

Washington Section Hears About Work of Navy and National Advisory Committee

Members of the Washington Section at the monthly meeting held on Feb. 2 were entertained by two very instructive papers. The first, by Lieut. B. G. Leighton, who is in charge of aeronautic engine development in the United States Navy, described the Recent Developments in Aircraft Engines in the Navy; the second, by George W. Lewis, executive officer of the National Advisory Committee for Aeronautics, discussed the progress that has recently been made in aeronautic research.

Confining himself closely to the subject and believing that an aircraft is only as good as the powerplant that sustains and propels it, Lieutenant Leighton outlined the trend of the successive improvements in engines that have increased the safety, durability, dependability and economy of aircraft. He showed that the standard of excellence has been gradually raised from the original 50-hr. test, which consisted of a series of 5-hr. runs at from 90 to 100 per cent of the rated output without failure of a "major" part, to the present requirement of 300 hr. of continuous running with wide-open throttle at sea-level. This would represent about 600 hr. of normal flying-service, and at a speed of 75 m.p.h. would be equivalent to about 45,000 miles of cruising. By successively redesigning the parts that have caused break-downs the maintenance cost has been reduced, the weight per brake horsepower and per inch of piston-displacement has been decreased, and the fuel consumption per brake horsepower has been lowered. The Packard 1A-1551 engine, which will be installed in our first rigid airship, has completed its test and shows a fuel consumption of 0.44 lb. per b.hp-hr. Of the lighter engines, the test of the Aeromarine U-8-D, an eight-cylinder V-type water-cooled engine, was satisfactory in every respect except in the weight per horsepower. When redesigned, the weight was materially decreased, the output increased and at the same time the durability was maintained, the original model weighing 575 lb. and developing 225 b.hp. at 1800 r.p.m. and the modified engine weighing 520 lb. and developing 260 b.hp. at the same speed. A still lighter model, the Wright E-2, having approximately the same characteristics as the U-8-D and being a development of the small Hispano-Suiza, has undergone satisfactory endurance tests, but several changes are being incorporated into a later model, the E-4.

The cost of overhauling aircraft, he said, is not generally appreciated, the standard Liberty engine requiring 300 man-hours of labor for overhauling after every 72 hr. of flying operation, that is, 4.2 hr. of overhauling labor at a cost of $6.30 for each hour of flying, or approximately 8.4 cents per mile. This does not include the cost of replacement parts.

Recent designs have demonstrated that a reduction of weight is possible without sacrificing either strength or durability; the Wright model T-2 weighs 1150 lb., has a piston-displacement of 1950 cu. in. and a normal output of 550 b.-hp.; the Curtiss model D-12 weighs 670 lb., has 1145-cu. in. piston-displacement and develops 375 b.-hp. at 1800 r.p.m.; and an experimental model now under construction will weigh 1150 lb., have a total piston-displacement of 2450 cu. in. and an assumed output of 775 hp. at 1800 r.p.m. At its rated output of 625 hp. the weight will be 1.80 lb. per hp.; at the designed horsepower it will be 1.55 lb. per hp.

Among the other subjects that have been investigated are the practicability of using larger cylinder-bores, the possibility of increasing the rotative speed and the brake mean effective pressure and the question of realizing a higher specific power and a lower specific fuel-consumption through the use of higher compression-ratios. The test of the Wright Model D-1, a six-cylinder vertical engine with 7-in. bore and 8-in. stroke, has demonstrated its entire suitability for dirigible service; the Wright model T-2 and the Curtiss model D-12 both have been run for hours at a 20-per cent overload without evidence of failure in any part; and the problem of higher compression is said to hinge entirely on the procuring of a fuel that will not only obviate detonation but will be available in large quantities at a reasonable cost. A blend containing 30 parts of alcohol and 70 parts of gasoline appears to meet these conditions.

Because of the large number on hand, although they have been falling behind the procession, the Liberty engines also have been undergoing a process of remodeling with a view to improving their durability, dependability and the weight factor. The predicted performance of the modified types indicates that a marked improvement in all these respects is to be expected.

With regard to the comparative merits of air-cooled and water-coolel engines, it is the opinion of Lieutenant Leighton, based on the results of 2 years of intensive testing, that there is nothing to indicate that the air-cooled engine is less efficient, flexible, powerful, dependable or durable, or more sensitive to changes in altitude or in temperature than the water-cooled engine; on the other hand, it is lighter, requires less preliminary running to warm-up in cold weather and less attention on the part of the pilot in flight, and its installation is distinctly simpler and cheaper. In the preliminary flights and in the early laps of the race at Detroit, two airplanes, identical in every respect except in powerplant, one being equipped with the Wright model E-2 water-cooled engine and the other with the Lawrance model J-1 air-cooled engine, appeared to be exactly equal in speed at the same propeller speed. The water-cooled type did not finish the race on account of a broken propeller tip. In the naval service the air-cooled engine in the smaller sizes, up to 300 hp., has definitely displaced the water-cooled engine. In commercial service, the argument is advanced that the saving of dead-weight by the use of air-cooled engines would increase the possible pay-load without in any way affecting the performance characteristics of the airplane.

Mr. Lewis' talk was illustrated by lantern-slides. After showing the original Wright airplane and describing the early efforts to fly, he contrasted the primitive types with those of the present day and included views of some of the gliders. The methods employed to solve airplane problems by the wind-tunnel were outlined, with special reference to the study of scale effect, and to the investigation of the distribution of forces over the various surfaces of airplanes, an investigation that has led to new methods of control and of construction and to the design of new types of instruments for measuring performance.

Past-President Bachman, Vice-President H. M. Crane, Mr. Van Ness, Mr. Lewis, R. M. Parsons, W. S. James, Lieutenant Leighton and Dr. H. C. Dickinson participated in the discussion.

PRESSURES IN GASEOUS EXPLOSIONS

On igniting a homogeneous inflammable gaseous mixture contained in a closed vessel, a sphere of flame with the point of ignition as the center spreads outward, slowly at first, and then with increasing speed. As the flame spreads, the potential chemical energy of the combustible gas is transformed into thermal energy, and the temperature and pressure of the burning gas rise in consequence. The pressure rises slowly at first and then rapidly until a maximum rate of pressure rise is attained, which remains constant for some time. Later, the rate of rise becomes less until the maximum pressure is reached, and afterward the pressure begins to decrease owing to the cooling action of the walls of the containing vessel. The period that elapses between the moment at which the pressure begins to rise, and the moment at which the pressure attains its maximum value, is known as the time of explosion.

The greater part of the burning takes place during the explosion period, but a considerable proportion of the gas remains unburnt at the moment of maximum pressure, and the combustion of this unburnt gas takes place as the mixture cools. An appreciable volume of inflammation also appears to take place before the pressure begins to rise, that is, during the period that elapses between the moment of passage of the ignition spark and the moment when the pressure begins to rise. This period has been termed the pre-pressure period.

It was predicted by Sir Dugald Clerk and experimentally confirmed by the late Prof. Bertram Hopkinson that the flame completely filled the explosion vessel some little time before the attainment of the maximum pressure. During the explosion of a 10-per cent mixture of coal-gas and air at atmospheric density in a vessel of 6.20-cu. ft. capacity, for which the time of explosion was 0.25 sec., Hopkinson found that the flame completely filled the vessel about 1/30 sec. before the attainment of the maximum pressure. The maximum pressure developed in this experiment was 82 lb. per sq. in., and the pressure at the moment when the flame completely filled the vessel had risen as high as 70 lb. per sq. in.

A very interesting point, first noticed by Hopkinson, is that the portions of the gas first ignited undergo adiabatic compression, due to an increase of the pressure developed by the later inflammation of the surrounding portions. Owing to this, the distribution of temperature in the gaseous mixture at the moment of maximum pressure is far from being uniform. The gaseous mixture at this moment consists of a hot core surrounded by cooler portions. In one of Hopkinson's experiments with a 10-per cent mixture of coal-gas and air, it was found that, while the mean temperature of the gaseous mixture at the moment of maximum pressure was about 1600 deg. cent. (2912 deg. fahr.), the temperature of the hot core was as much as 1900 deg. cent. (3452 deg. fahr.).

In some experiments made with an optical indicator with a high-frequency spring, when the spark was placed in the center of the vessel, the time of explosion was less and the maximum pressure developed was greater than when the spark was placed near one end of the vessel. In the former case, the time of explosion was 0.050 sec. and the maximum pressure 105 lb. per sq. in. above that of the atmosphere, and in the latter case 0.075 sec. and 100 lb. per sq. in.

Curves were taken with a 15.0-per cent mixture composed of 15 parts of coal-gas and 85 parts of air, with a 12.5-per cent mixture and with a 10.0-per cent mixture. All the gaseous mixtures were at atmospheric pressure before firing. In the strong mixture a maximum pressure of 105 lb. per sq. in. above that of the atmosphere was developed in 0.056 sec.; in the medium mixture, 90 lb. per sq. in. in 0.075 sec.; and in the weak mixture, 76 lb. per sq. in. in 0.140 sec. The 15-per cent mixture required practically the whole of the oxygen in the air for its complete combustion. The weakest mixture of this coal-gas that would ignite on the passage of the spark contained between 7 and 8 per cent of coal-gas.

Similar curves were taken of hydrogen-and-air mixtures of 25.0 per cent, 15.3 per cent and 10.0 per cent. The strong mixture gave a maximum pressure of 87 lb. per sq. in. above atmosphere in 0.014 sec., the medium mixture a maximum pressure of 61 lb. per sq. in. in 0.060 sec., and the weak mixture a maximum pressure of 44 lb. per sq. in. in 0.250 sec.

The time of explosion increases slightly with the density; at ½ atmosphere it is 0.0420 sec., while at 1 atmosphere it is 0.0500 sec., and at 1½ atmospheres 0.0575 sec. The ratio of the maximum absolute-pressure to the initial pressure increases slightly with the density. At ½ atmosphere this ratio is about 7.75, while at densities of 1 atmosphere and over it is a little greater than 8.00. This is due mainly to the relative decrease in the heat-loss during the explosion period as the density is increased.

Sir Joseph Petavel, experimenting with coal-gas and air mixtures at very high densities, also found that the ratio of the maximum to the initial pressure increases with the density. Thus, for a particular mixture at about 75 atmospheres this ratio was about 8.6, whereas for the same mixture at atmospheric density in the same explosion vessel, the ratio was about 7.0.

Effect of Interior Finish

The interior surface of the explosion vessel was silver-plated and could therefore be made either reflecting by polishing or absorbent as regards radiation by blackening. With two identical 15-per cent mixtures of coal-gas and air, but in the one case the walls of the vessel being polished, and in the other case blackened, the maximum pressure was about 3 per cent greater and the rate of cooling much slower with the polished vessel. This is a result first discovered by Hopkinson. The reason for the greater pressure and the slower cooling in the polished vessel is that the radiation emitted by the hot gaseous mixture is reflected back by the walls and reabsorbed by it.

With 25-per cent mixtures of hydrogen and air exploded under similar conditions as the coal-gas mixtures, the rate of cooling in the polished vessel is considerably less than that in the blackened vessel, but the maximum pressure in the polished vessel is not appreciably greater than that in the blackened vessel. This is due to the fact that the amount of radiation emitted during the very short explosion period is very small.

Effect of Inert Carbon Dioxide

In replacing the nitrogen of the air by inert carbon dioxide, a 15-per cent mixture of coal-gas and air composed of 15.0 per cent of coal-gas, 17.8 per cent of oxygen and 67.2 per cent of nitrogen; a mixture containing 15.0 per cent of coal-gas, 26.4 per cent of oxygen, and 58.8 per cent of carbon dioxide; and a mixture containing 15.0 per cent of coal-gas, 19.7 per cent of oxygen and 65.3 per cent of carbon dioxide, the presence of carbon dioxide reduces greatly the maximum pressure developed and slows down the speed of combustion; further, the greater the proportion of carbon dioxide, the lower the pressures and the slower the burning. The lower maximum-pressures produced in the carbon-dioxide mixtures are due in a large measure to the greater volumetric or specific heat of carbon dioxide as compared with that of nitrogen. Probably, too, in the carbon-dioxide mixtures rather less of the coal-gas is burnt at the moment of maximum pressure than in the nitrogen mixtures.—Prof. W. T. David in *Engineering* (London).

Applicants *Qualified*

The following applicants have qualified for admission to the Society between Jan. 10 and Feb. 10, 1923. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff) Affiliate; (S M) Service Member; (F M) Foreign Member; (E S) Enrolled Student.

ANDO, CHIYO (F M) designer and production manager, Nakashima Aircraft Works, *Ota, Gunmaken, Japan.*

AUSTIN, SAMUEL (A) service manager, Austin Automobile Co., 19 Seyms Street, *Hartford, Conn.*

BAGGS, H. S. (A) president, Norfleet-Baggs, Inc., South Main Street, *Winston-Salem, N. C.*

BAYLESS, RAY T. (M) chemical engineer and metallurgist American Society for Steel Treating, *Cleveland,* (mail) 4600 Prospect Avenue.

BEAL, H. S. (A) assistant general manager, Jones & Lamson Machine Co., *Springfield, Vt.,* (mail) 27 Orchard Street.

BLACKINTON, GEORGE WILSEY (M) works manager, Continental Motors Corporation, *Detroit,* (mail) 160 Grand Boulevard.

BOHLEN, CHARLES (J) draftsman, International Motor Co., *New York City,* (mail) 950 Union Avenue.

BROWN, JAY R. (M) chief engineer, Western Automatic Machine Screw Co., *Elyria, Ohio,* (mail) 246 George Street.

CALLUM, JOHN R. (A) designer and builder of racing cars, J. R. Callum & Co., *Norfolk, Va.,* (mail) 1700 West Ghent Boulevard.

CHILDS, WILL P. (M) manager, Western Screw & Specialty Co., *Racine, Wis.,* (mail) 1508 Main Street.

CORNFORTH, R. GARDNER (J) chief engineer, Nice Ball Bearing Co., *Philadelphia,* (mail) 2047 West Tioga Street.

DE LA VERGNE MACHINE CO. (Aff) Foot of East 138th Street, *New York City.*
Representative:
Doelling, Louis, general manager.

DICK, JAMES B. (A) production engineer, D'Arcy Spring Co., *Kalamazoo, Mich.,* (mail) 810 North Burdick Street.

ELLEMAN, THOMAS H. (A) research engineer, General Motors Research Corporation, *Dayton, Ohio,* (mail) R. F. D. No. 16.

ELLIS, CAPT. CARROLL L. (S M) tank department, *Aberdeen Proving Ground, Md.*

FORBES, MYRON EDSON (A) president, Pierce-Arrow Motor Car Co., *Buffalo, N. Y.*

FORD, E. LOUIS, JR. (E S) student, Yale University, *New Haven, Conn.,* (mail) 38 Hubinger Street.

FORDHAM, THOMAS B. (M) superintendent, Delco-Light Co., *Dayton, Ohio.*

FOSTER, WILLIAM J. (S M) aeronautical mechanical engineer, Air Service, McCook Field, *Dayton, Ohio,* (mail) care E. C. Doren, R. F. D. No. 1, Salem Pike.

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GUBITZ, WERNER (J) Springfield Body Corporation, 1819 Broadway, *New York City.*

GULF REFINING CO. (Aff) Frick Building Annex, *Pittsburgh.*
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Beatty, C. G., sales department, New York City.
Douglas, S. T., sales department, Boston.
Graham, H. B., chief lubrication engineer.
Hobart, H. P., manager, lubricating department.
Mathis, H. C., sales department, Philadelphia.

HANNUM, G. H. (M) president and general manager, Oakland Motor Car Co., *Pontiac, Mich.*

HAYLETT, R. E. (M) assistant manager, manufacturing department, Union Oil Co. of California, Los Angeles, (mail) Union Oil Co. of Cal., *Wilmington, Cal.*

HECKMAN, J. A. (J) treasurer, Heckman Signal Co., Denver, (mail) 1328 North 17th Street, *St. Louis.*

HERBRAND CO. (Aff) *Fremont, Ohio.*
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JEFFRIES, SCHUYLER A. (M) engineering department, Reo Motor Car Co., *Lansing, Mich.*

JONES, AUGUST F. (E S) student, Cornell University, *Ithaca, N. Y.,* (mail) 519 Stewart Avenue.

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LEHMAN, MILTON S. (E S) student, Ohio State University, *Columbus, Ohio,* (mail) 174 East Woodruff Avenue.

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LYTLE, R. W. (M) assistant chief engineer, Stephens Motor Works of Moline Plow Co., *Freeport, Ill.*

MCQUADE, HARRY W. (M) vice-president and chief engineer, National Pressed Gear Co., *Canton, Ohio,* (mail) P. O. Box 432.

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OTT, T. F. (M) superintendent of the lubricating division, manufacturing department, Union Oil Co. of California, Los Angeles, (mail) *Oleum, Cal.*

PARCELL, EARL W. (A) designing engineer, Fairbanks, Morse & Co., *Beloit, Wis.,* (mail) 632 Milwaukee Road.

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PEASE, FRANK D. (J) laboratory engineer, Studebaker Corporation, *Detroit,* (mail) 2486 LaMathe Avenue.

PLACE, REUBEN MEREDITH (A) branch manager, Ahlberg Bearing Co., Chicago, (mail) 142 Tenth Street, *Toledo.*

PORTER, ROLLAND C. (J) designer, Prudden plant, Motor Wheel Corporation, *Lansing, Mich.,* (mail) 717 West Michigan Avenue.

PRESTON, L. H. (A) Ansted Engineering Co., *Connersville, Ind.*

RENOLD, INC., HANS (Aff) 365 Broadway, *New York City.*
Representatives:
George, H., vice-president.
Joy, J., engineer.
Mills, E. W., treasurer.

ROCCHETTI, JOSEPH (M) chief engineer, Manitoba Power Commission, *Winnipeg, Man., Canada.*

SANFORD, ROY S. (A) inventor, Sanford Fore-Wheel Brake Co., *Pasadena, Cal.,* (mail) 20 South Vernon Avenue.

SCHNEPEL, HERBERT (J) layout draftsman, Nordyke & Marmon Co., *Indianapolis,* (mail) 250 Oxford Street.

SHOEMAKER, FRED R. (E S) student, University of Illinois, Urbana, Ill., (mail) 406 East Healy Street, *Champaign, Ill.*

SKURRAY, ERNEST C. (A) engineer, Skurray's, *Swinton, Wiltshire, England.*

SLOCOMBE, W. VERNON (A) assistant engineer in charge of production, Turbulator Corporation, *Chicago,* (mail) 2711 North Kedzie Avenue.

THORSON, WILBUR R. (J) assistant manager, Central Iowa Electric Co., McCallsburg, Iowa, (mail) P. O. Box 452, Station A, *Ames, Iowa.*

TODD, FILLMORE W. (A) president, Accessories Mfg. Co., 2311 North Crawford Avenue, *Chicago.*

TREVELYAN, HARRY A. (M) assistant superintendent of inspection, Studebaker Corporation of America, *Detroit,* (mail) 5038 Crane Avenue.

USHIODA, SEIKICHI (E S) student, Cornell University, *Ithaca, N. Y.,* (mail) 201 Bryant Avenue.

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WALLACE, DONALD E. (A) experimental engineer, Shakespeare Co., *Kalamazoo, Mich.,* (mail) 810 Davis Street.

WARNER, W. M. (A) manager, parts department, Cadillac Motor Car Co., *Detroit.*

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WHITE, KARL H. (J) aeronautical engineer, Aeromarine Plane & Motor Co., *Keyport, N. J.,* (mail) 162 Church Street.

WHITEHEAD, J. FRAZER (A) secretary and treasurer, Kales Stamping Co., 1657 West Lafayette Boulevard, *Detroit.*

WILLIAMS, EMERSON MARION (E S) student, University of Michigan, *Ann Arbor, Mich.,* (mail) 719 Church Street.

WOLLERING, MAX F. (M) vice-president, Studebaker Corporation of America, *Detroit,* (mail) 36 McLean Street.

YACKEY, HAROLD HILGARD (E S) student, University of Illinois, *Urbana, Ill.,* (mail) 1003 West Nevada Street.

Applicants *for* Membership

The applications for membership received between Jan. 15 and Feb. 15, 1923, are given below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

ANDERSON, CHARLES S., student, New York University, *New York City.*

ALEXANDER, DONALD, Edward G. Budd Mfg. Co., *Philadelphia.*

BAIN, GERALD, *Haynesville, La.*

BALLENTINE, WILLIAM I., vice-president, Advance-Rumely Co., *La Porte, Ind.*

BANES, WILLIAM K., carbureter expert, U. S. Industrial Alcohol Co., *Baltimore.*

BENÉT, LAURENCE V., vice-president, Hotchkiss & Cie., *St. Denis (Seine) France.*

BERKOWITZ, IRVING H., engineer, Diamond Taxi-Cab Co., *New York City.*

BLOSSOM, ROY E., special sales representative, Prest-O-Lite Co., Inc., *Indianapolis.*

BOWMAN, JOHN ALDEN, comptroller, John W. Brown Mfg. Co., *Columbus, Ohio.*

BUNNELL, FRED H., student, Michigan Agricultural College, *East Lansing, Mich.*

CAMPBELL, FRED J., chief draftsman, Falls Motors Corporation, *Sheboygan Falls, Wis.*

CATLIN, AUREL A., student, Michigan Agricultural College, *East Lansing, Mich.*

CLEMENS, FRED J., mechanical superintendent, Robert Mfg. Co., *New Haven, Conn.*

COLLINS, P. A., technical service department, Reo Motor Car Co., *Lansing, Mich.*

COOK, WALTER, student, Michigan Agricultural College, *East Lansing, Mich.*

CROWE, G. FRANCIS, student, University of Toronto, *Toronto, Ont., Canada.*

CRUDEN, J. P., district sales manager, Standard Oil Co., *Walla Walla, Wash.*

DAVIE, ARTHUR J., student, Michigan Agricultural College, *East Lansing, Mich.*

DEGENER, PAUL A., president, Rochester Motors Corporation, *New York City.*

DONNER STEELE CO., INC., *Buffalo, N. Y.*

DOWNEY, J. S., salesman, Chanslor & Lyon Co., *Los Angeles.*

DRAKE, HAROLD, airplane designer, G. Elias & Bro., *Buffalo.*

DRUMM, EDGAR A., principal of Y. M. C. A. automobile school, *City of Washington.*

DUNBAUGH, GEORGE J., JR., secretary, Champion Mfg. Co., *Chicago.*

ESKOWIT, ISADORE, student, Polytechnic Institute of Brooklyn, *Brooklyn, N. Y.*

FAIRBANK, CHARLES WILLIAM, test engineer, Standard Oil Co. of New Jersey, *Baltimore.*

FALCONER, JOHN WILLARD, student, Armour Institute of Technology, *Chicago.*

FRANCIS, PHILIP W., Yorktown Motor Co., *Yorktown Heights, N. Y.*

FRANCIS, TENCH, Yorktown Motor Co., *Yorktown Heights, N. Y.*

GLEISEN, D., manager, Eastern division, Hyatt Roller Bearing Co., *New York City.*

GRATWICKE, WALTER, engineer, British Aluminum Co., Ltd., *New York City.*

GREENE, WHITNEY E., instructor, Pennsylvania State College, *State College, Pa.*

HACKETT, FRANK J., service manager, Sills-Chevrolet Co., *Boston.*

HACKHAM, GEORGE JOHN, chief engineer, Yellow Coach Mfg. Co., *Chicago.*

HAIGH, JAMES H., student, Michigan Agricultural College, *East Lansing, Mich.*

HANNING, JAMES ROWLAND, student, University of Toronto, *Toronto, Ont., Canada.*

HARTSHORN, STANLEY DENTON, student, Massachusetts Institute of Technology, *Cambridge, Mass.*

HAPPERSETT, ROLAND H., student, Tri-State College, *Angola, Ind.*

HIGGINS, WILLIAM H. C., chief engineer, Advance-Rumely Co., *LaPorte, Ind.*

HOFFMAN, E. E., chief engineer, Hendee Mfg. Co., *Springfield, Mass.*

HOLMES, LAWRENCE J., factory manager, International Motor Co., *Allentown, Pa.*

HUGHES, LLOYD I., student, Michigan Agricultural College, *East Lansing, Mich.*

INGERSOL, AUSTIN O., student, Michigan Agricultural College, *East Lansing, Mich.*

JACKSON, LEE R., district manager, Firestone Tire & Rubber Co., *Detroit.*

JAYCOX, RANDALL EUGENE, automobile repairman, Oak Ridge Oil Co., *Santa Paula, Cal.*

JUDSON, ARTHUR, vice-president, Fuller & Smith, *Cleveland.*

KELLER, A., vice-president and works manager, Golde-Patent Mfg. Co., *New York City.*

KINNEY, ALDON M., assistant superintendent, Cropper-Kinney Auto Spring Co., *Lebanon, Ohio.*

KLINGER, G. W., engineer of tests, and manager of automotive department, Vibration Specialty Co., *Philadelphia.*

LEAVER, ALBERT JOSEPH, consulting automotive engineer, *Brisbane, Queensland, Australia.*

LEROY, B. L., engineer, Beans Spring Co., *Massillon, Ohio.*

LEWIS, WERNER H., student, Michigan Agricultural College, *East Lansing, Mich.*

LITTLE, J. GRIFFIN, student, Michigan Agricultural College, *East Lansing, Mich.*

LOGAN, G. L., technical service department, Packard Motor Car Co., *Detroit.*

LUCKETT, DINWIDDIE J., ordnance engineer, design section, Ordnance Department, *Rock Island Arsenal, Ill.*

MCADAM, D. J., JR., metallurgist, Naval Engineering Experiment Station, *Annapolis, Md.*

MACDONALD, W. W., chief engineer, MacDonald Truck Division, Union Construction Co., *Oakland, Cal.*

MACK, WILLIAM, sales manager, Borg & Beck Co., *Chicago.*

MARKEY, ROSCOE I., aeronautic designer, engineering division, Air Service, McCook Field, *Dayton, Ohio.*

MAXIM, ALBERT, engineering mechanic, Ward Motor Vehicle Co., *Mount Vernon, N. Y.*

MEIGS, DWIGHT R., vice-president, U. S. Axle Co., *Pottstown, Pa.*

MEYER, ALVIN W., mechanic, Waddams Garage, *Waddams Grove, Ill.*

MORRISH, NEIL B., student, Michigan Agricultural College, *East Lansing, Mich.*

MORRISON, EARL L., student, Michigan Agricultural College, *East Lansing, Mich.*

OTTENHOFF, W. B., manager of engineering and service division, Indian Refining Co., Inc., *New York City.*

PEASLEE, W. D. A. chief engineer, Belden Mfg. Co., *Chicago.*

PFEIFFER, ARTHUR E., student, University of Illinois, *Urbana, Ill.*

PLATZ, HENRY A., student, Michigan Agricultural College, *East Lansing, Mich.*

POKORNY, FRANK, experimental engineer and president, Rex Motor Control, *Mamaroneck, N. Y.*

PORTER, H. K., directing engineer, Eastern division, Hyatt Roller Bearing Co., *New York City.*

PRESBREY, OTIS FLAGG, instructor, Polytechnic Institute of Brooklyn, *Brooklyn, N. Y.*

RABIDOUX, EDWARD J., service supervisor, Reo Motor Car Co. of New York, *New York City.*

REED, NEWTON L., superintendent of motor equipment, Crew Levick Co., *Philadelphia.*

ROBB, WILLIAM C., assistant manager, Ohio Rubber Co., *Detroit.*

SCHWEITZER, PAUL H., mechanical engineer and tool designer, Oakland Motor Car Co., *Pontiac, Mich.*

SHERWOOD, H. H., president, Sherwood Petroleum Co., Inc., *Brooklyn, N. Y.*

SLAKER, CHARLES S., general manager, Hayes Wheel Co., *Jackson, Mich.*

SLATTERY, MICHAEL W., instructor, Arsenal Technical Schools, *Indianapolis.*

SMALL, FRED FULTON, mechanical superintendent, Pacific Electric Railway Co., *Los Angeles.*

SOHLINGER, W. J., vice-president and general manager, Flint Varnish & Color Works, *Flint, Mich.*

SPENCER, ROBERT D., student, Michigan Agricultural College, *East Lansing, Mich.*

SPERLING, EZRA F., student, Michigan Agricultural College, *East Lansing, Mich.*

STIFF, MASON C., student, Michigan Agricultural College, *East Lansing, Mich.*

STILGER, WILLIAM M., parts manager, Hudson Motor Co. of Illinois, *Chicago.*

TELFORD, MARSHALL H., student, Tri-State College, *Angola, Ind.*

THOMSON, WILLIAM G., automobile mechanic, Consumers Ice Co., *San Francisco.*

TRANSCONTINENTAL OIL CO., *Pittsburgh.*

TRUSCOTT, PERCY JOHN, student, Michigan Agricultural College, *East Lansing, Mich.*

WACHTLER, WILLIAM B., directing engineer, Hyatt Roller Bearing Co., *Newark, N. J.*

WADIA, J. R., automobile engineer, c/o Mathews & Co., *Bombay, India.*

WATANABE, TORAJIRO, professor, College of Engineering, Waseda University, *Tokyo, Japan.*

WELSH, JAMES W., executive secretary, American Electric Railway Association, *New York City.*

WHARAM, JOHN H., assistant engineer, Lincoln Motor Co., *Dearborn Mich.*

WILD, MARK, works manager, Meteor Works, Rover Co., Ltd., *Coventry, England.*

WILLIAMS, FRANCIS, sales manager, Gardner Waern & Co., Ltd., *Melbourne, Victoria, Australia.*

WRIGHT, J. R., research engineer, Standard Oil Co. of New Jersey, *Elizabeth, N. J.*